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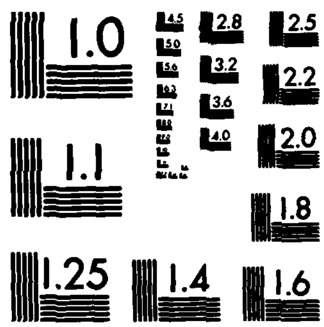

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DETERMINATION OF AMMUNITION TRAINING RATES FOR MARINE FORCES STUDY - VOL II

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DEVELOPMENT CENTER
MARINE CORPS DEVELOPMENT AND EDUCATION COMMAND
QUANTICO, VIRGINIA 22134

17 SEPTEMBER 1983

FINAL REPORT

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COMMANDANT OF THE MARINE CORPS
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study determined the ammunition expenditures necessary to attain and maintain required levels of proficiency for individuals and units. Previously, very little consideration was given to levels of desired proficiency in determining allowances. The study focused on the determination of training allowances based on the attainment of individual training standards in formal schools as well as in operational units; the maintenance of individual training standards; and the attainment and maintenance of

unit training standards. Additionally, subcaliber and simulator training were assigned a quantitative value relative to the value of live-fire training. Lastly, the study addressed the methodology whereby training allowances would be responsive to changes in weapons, tactics, doctrine and budget constraints. The methodologies developed by the study provide a sound basis for determining training allowances and identified a logical alternative allowance system based on the organization vice the per weapon allowance system currently in use.

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From: Commandant of the Marine Corps
To: Distribution List

Subj: DETERMINATION OF AMMUNITION TRAINING RATES FOR MARINE FORCES STUDY

1. The objective of this study, as modified, was to obtain a methodology to collect the data and to compute allowances for training ammunition.

2. The objective of the study was accomplished.

3. The conclusions and recommendations of the study have been accepted with minor modifications. The first is that the collection of hard data will be held in abeyance until the Marine Corps can evaluate data that has been collected by the U.S. Army. In addition, the timing of the recommendation to institute data collection will be deferred until fiscal year 1986.

4. This study is approved for public release; distribution unlimited.

5. A copy of this letter will be affixed inside the front cover of each copy of the subject study prior to its distribution.

Ray M. Franklin

Ray M. FRANKLIN
BRIGADIER GENERAL, U.S. MARINE CORPS
DEPUTY CHIEF OF STAFF FOR RD&S

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

LIST OF TABLES

ANNEX A

TANK SURVEY RESULTS AND CALCULATIONS

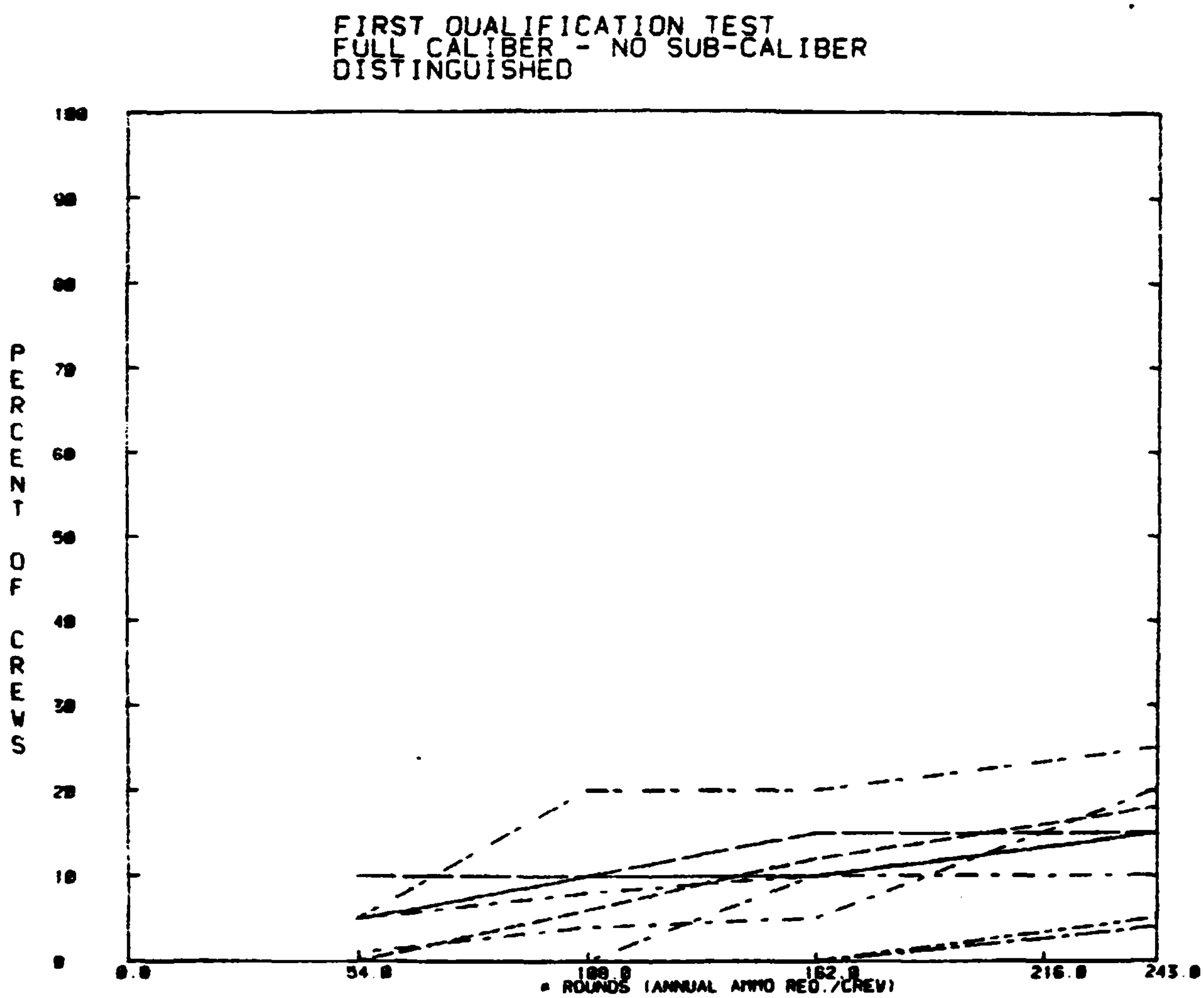
A. INTRODUCTION

This annex contains all of the detailed information from the Tank Gunnery Questionnaire. Paragraph 2 contains the detailed responses as well as plots of the data showing key results. ~~Paragraph 3 presents~~ the methodology used in estimating total ammunition usage for a change in the allocation of ammunition; ~~Paragraph 4 presents~~ the statistical methods to be used in analyzing the hard data collected in the test program proposed in Chapter III, Section 3 of the main body of the report. Tab A-1 provides a copy of the Tank Gunnery Questionnaire.

B. SURVEY RESULTS

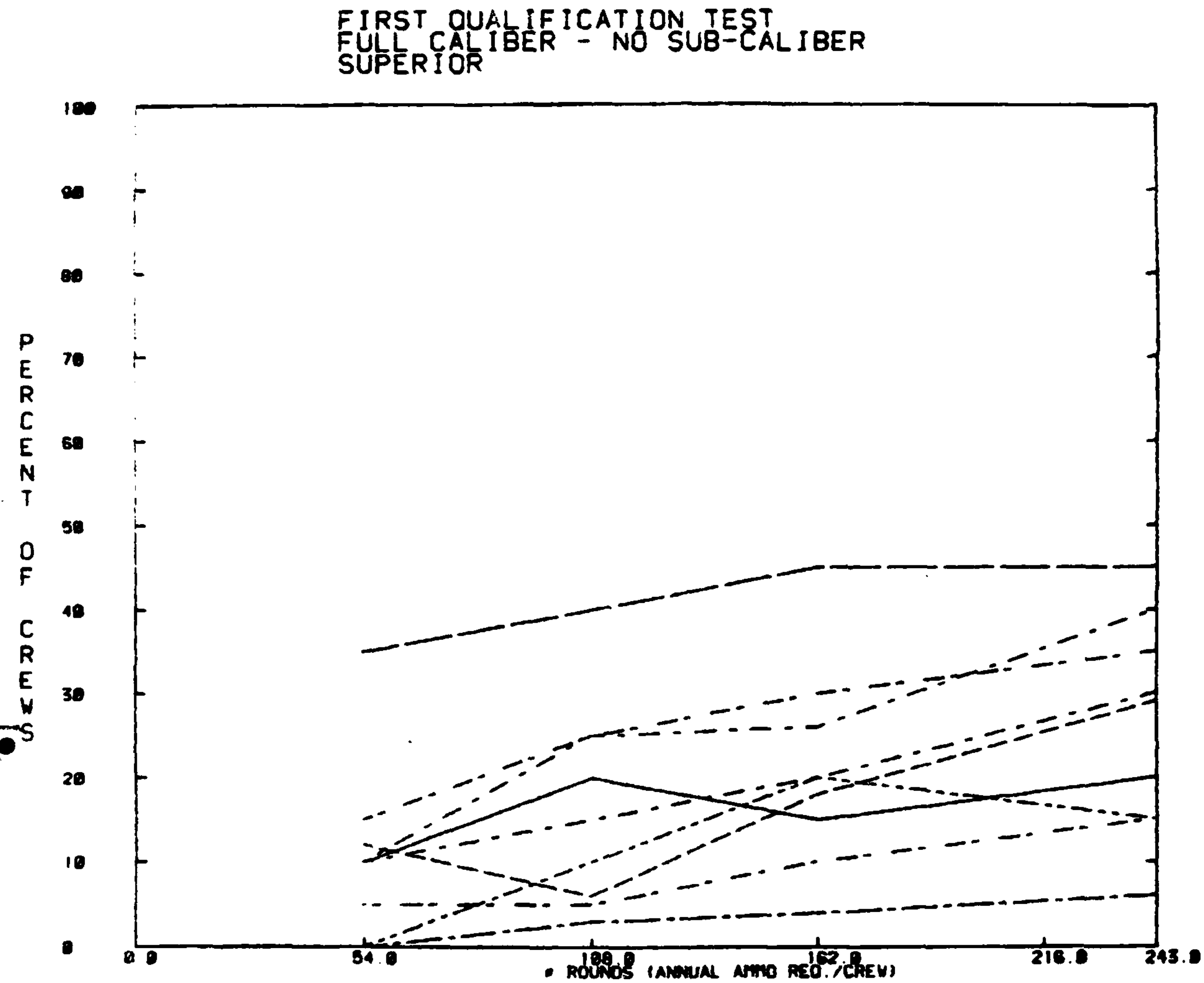
Figures A-1 through A-13 summarize some of the key findings from the questionnaire. Figures A-1 through A-6 present the data on the test of changes in the application of full caliber ammunition. Figures A-1, A-2, A-3 and A-4 present the proportion of crews in each of four categories: distinguished, superior, qualified and unqualified. Figure A-5 shows the number of crews in the total qualified category (distinguished, superior, and qualified). Summary data in the form of maximum, minimum, mean and standard deviation values are shown in Figure A-6. The effects of using subcaliber ammunition as a substitute for full caliber and the use of pre-table simulation are shown in Figures A-7 through A-9.

All of the data shown in Figures A-1 through A-9 demonstrate the lack of agreement among experts in the Marine Corps on the standards for tank gunnery and on the proficiency of the crews. The standard deviation lines on curves are very close to the maximum and minimum values of the data, demonstrating the even distribution of data across the range of values given. The detailed plots, such as found in Figures A-1 through A-4, show that there is more consistency in the slopes of the curve. This means that



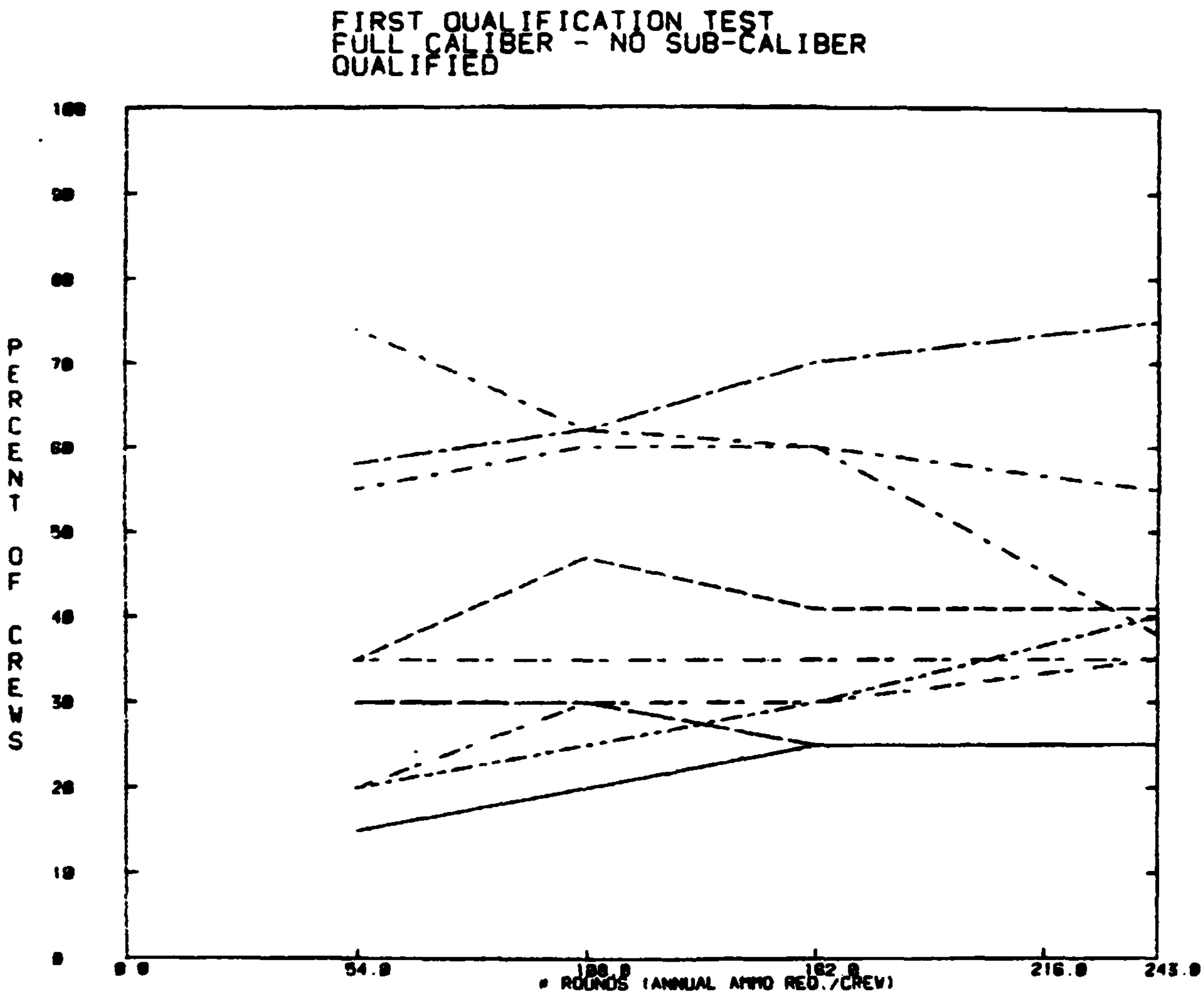
Note: Each Curve Represents the Response of One Survey Participant

Figure A-1. Crews Rated "Distinguished" as a Function of Full Caliber Rounds (First Qualification)



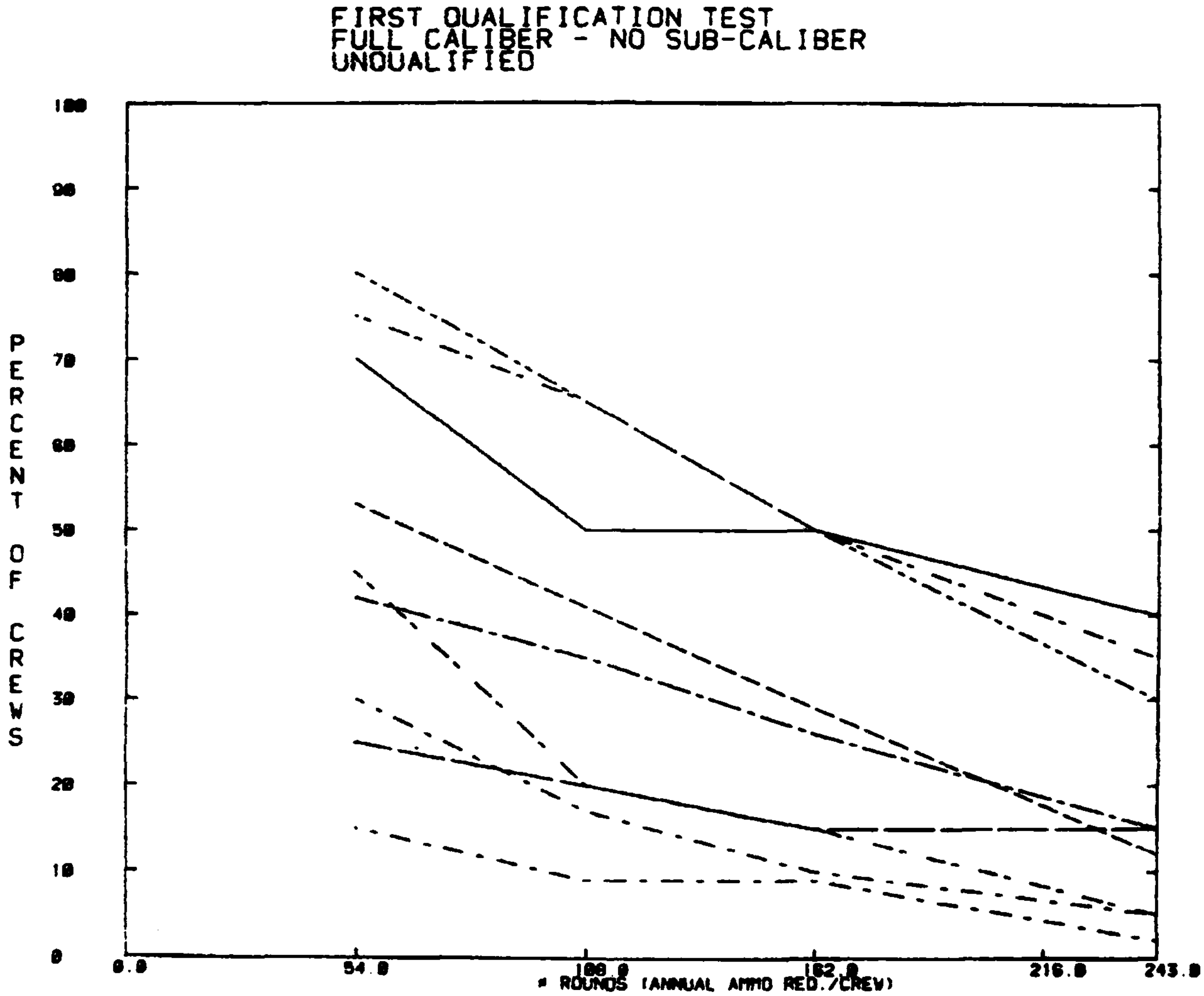
Note: Each Curve Represents the Response of One Survey Participant

Figure A-2. Crews Rated "Superior" as a Function of Full Caliber Rounds (First Qualification)



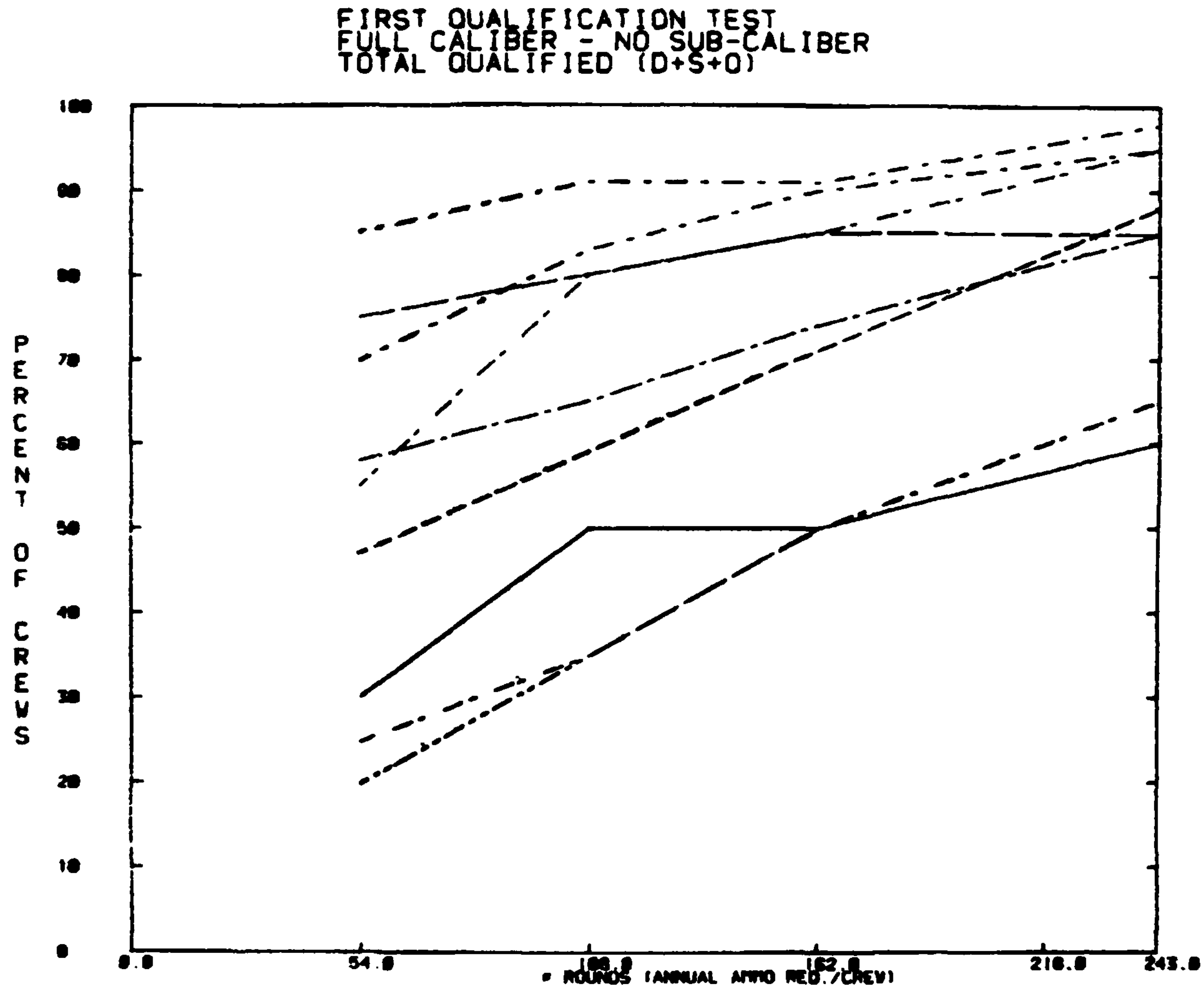
Note: Each Curve Represents the Response of One Survey Participant

Figure A-3. Crews Rated "Qualified" as a Function of Full Caliber Rounds (First Qualification)



Note: Each Curve Represents the Response of One Survey Participant

Figure A-4. Crews Unqualified as a Function of Full Caliber Rounds (First Qualification)



Note: Each Curve Represents the Response of One Survey Participant

Figure A-5. Crews Qualified in All Categories as a Function of Full Caliber Rounds (First Qualification)

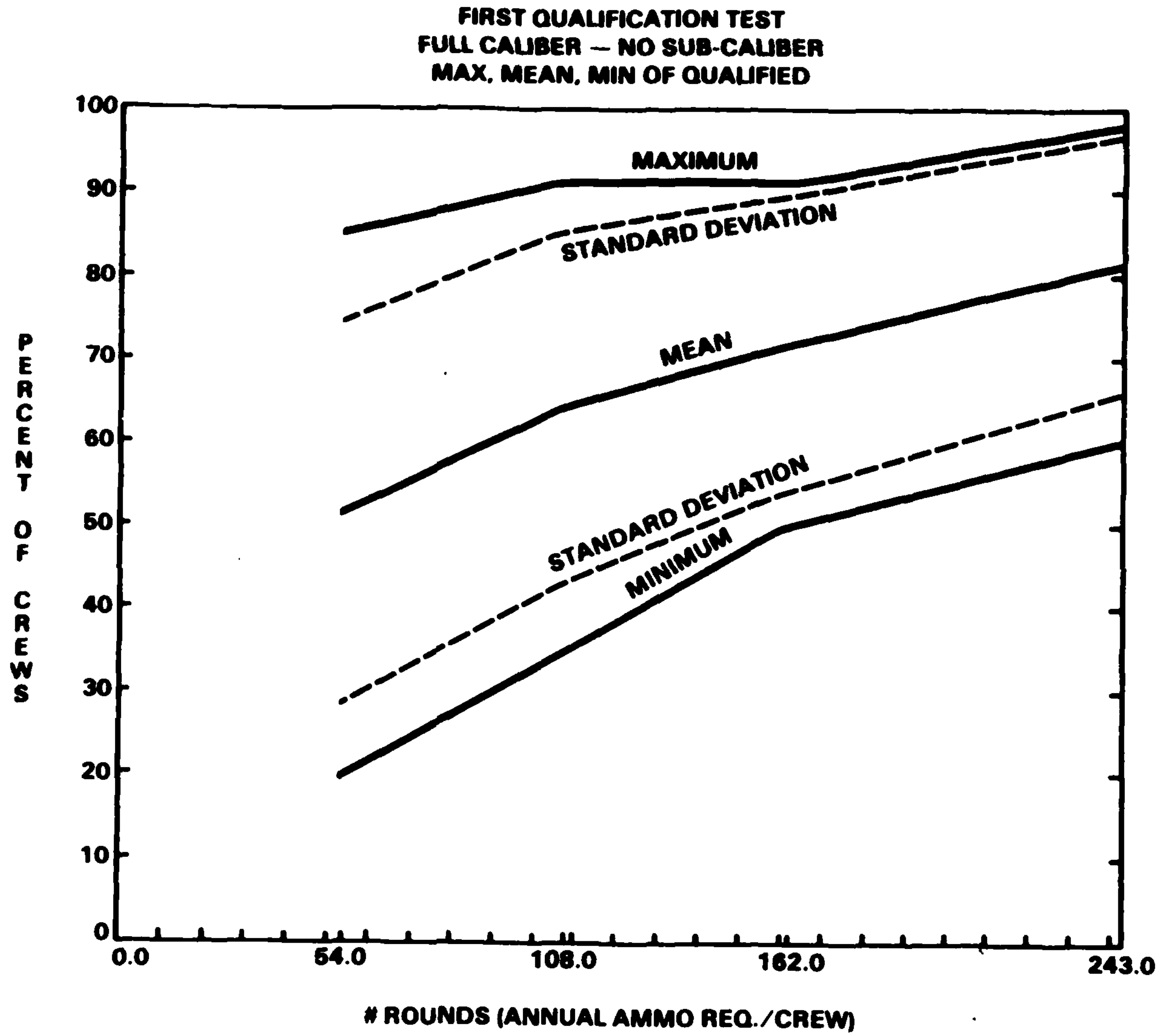


Figure A-6. Summary Data on Crews Qualifying in All Categories as a Function of Full Caliber Rounds (First Qualification)

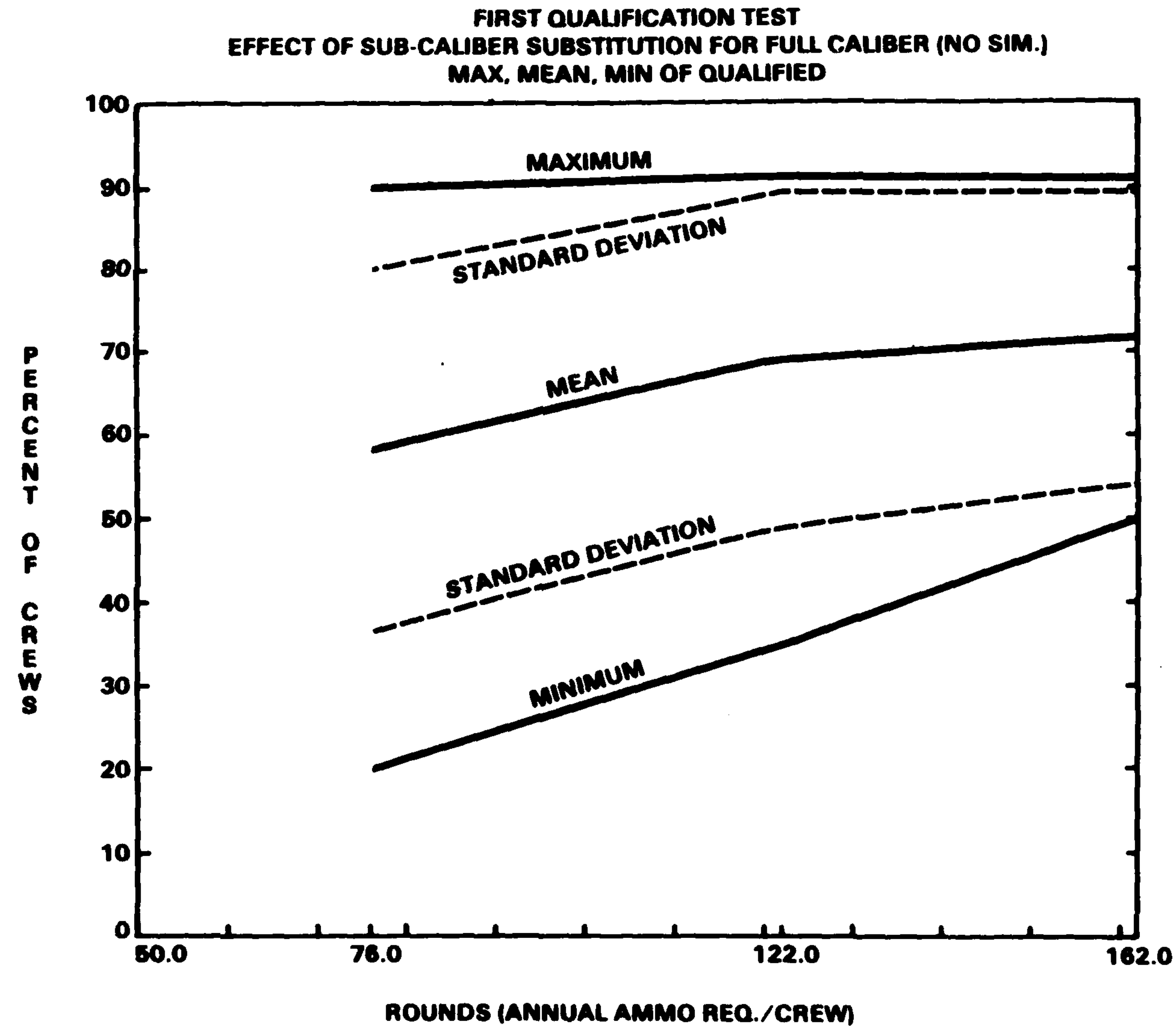


Figure A-7 Effect of Subcaliber Substitution with No Simulation (First Qualification)

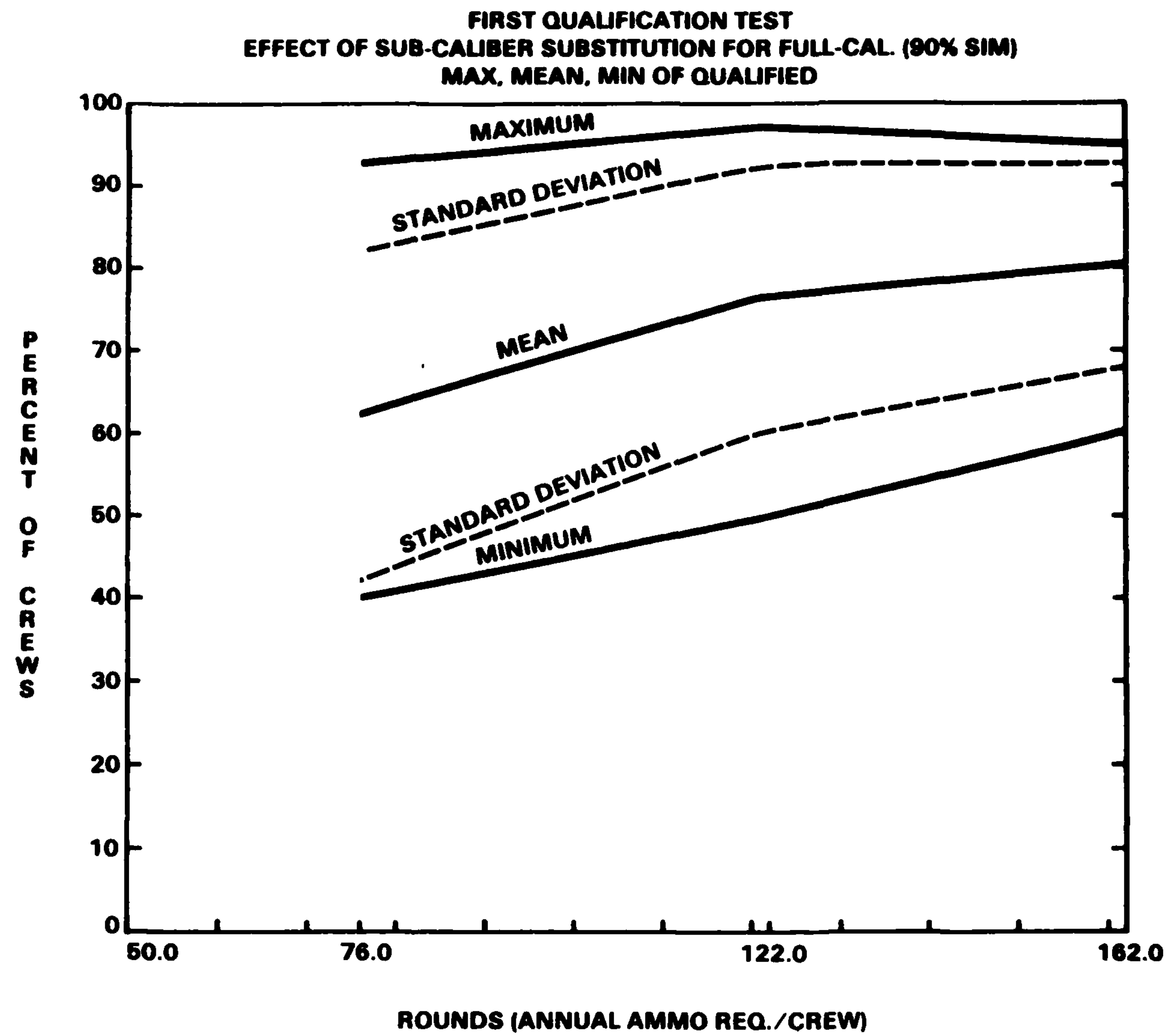


Figure A-8. Effect of Subcaliber Substitution with 90% Pre-table Simulation (First Qualification)

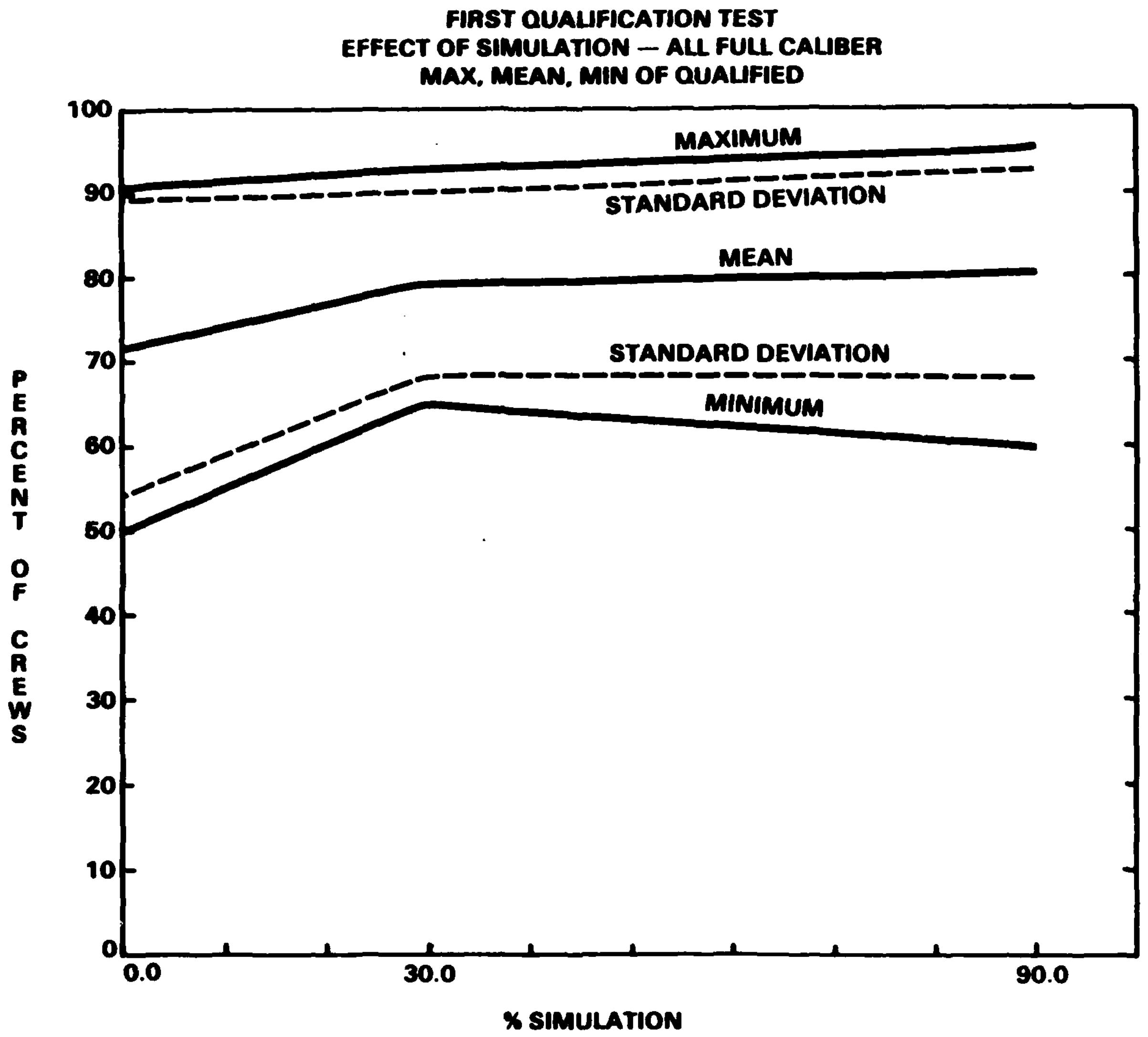


Figure A-9. Effect of Simulation with All Full Caliber (First Qualification) there is more agreement on the effects of changing the level of ammunition provided.

The effects on crew qualification of turbulence and the frequency of training are shown in Figures A-10 and A-11, respectively. The data vary widely in magnitude but show some consistency in the amount of change in the proportion of crews qualifying with increasing turnover and increasing time between training events. Platoon results are very similar to crew results, as shown by Figure A-12. There is wide variation in the data estimates but not in the proportion of those who qualify in relation to the amount of ammunition allocated. Turbulence effects and the effects of frequency of training are shown for platoons in Figures A-13 and A-14.

All of the data presented in Figures A-1 through A-14 are for crews and platoons qualifying for the first time. The questionnaire also asked for information on crews and platoons which qualified the preceding year. Figure A-15 presents a sample result for such crews. The proportion expected to qualify is higher, reflecting the greater experience of these crews.

C. AMMUNITION USAGE

This paragraph presents the methodology for computing total ammunition requirements for the reshoot training concept presented in Chapter III, Section B. The procedure involves reducing the initial allocation of ammunition and then providing the crews and platoons that failed their first attempt as much additional ammunition as they need to qualify. The computation produces an estimate of factor or multiple of the basic ammunition allocation required for this training concept. The equation used is as follows:

$$F = (Q_T + UR)\,A_F$$

where F = Factor of basic ammunition allocation;

Q_T = the proportion of crews in the total qualified category (superior, distinguished and qualified);

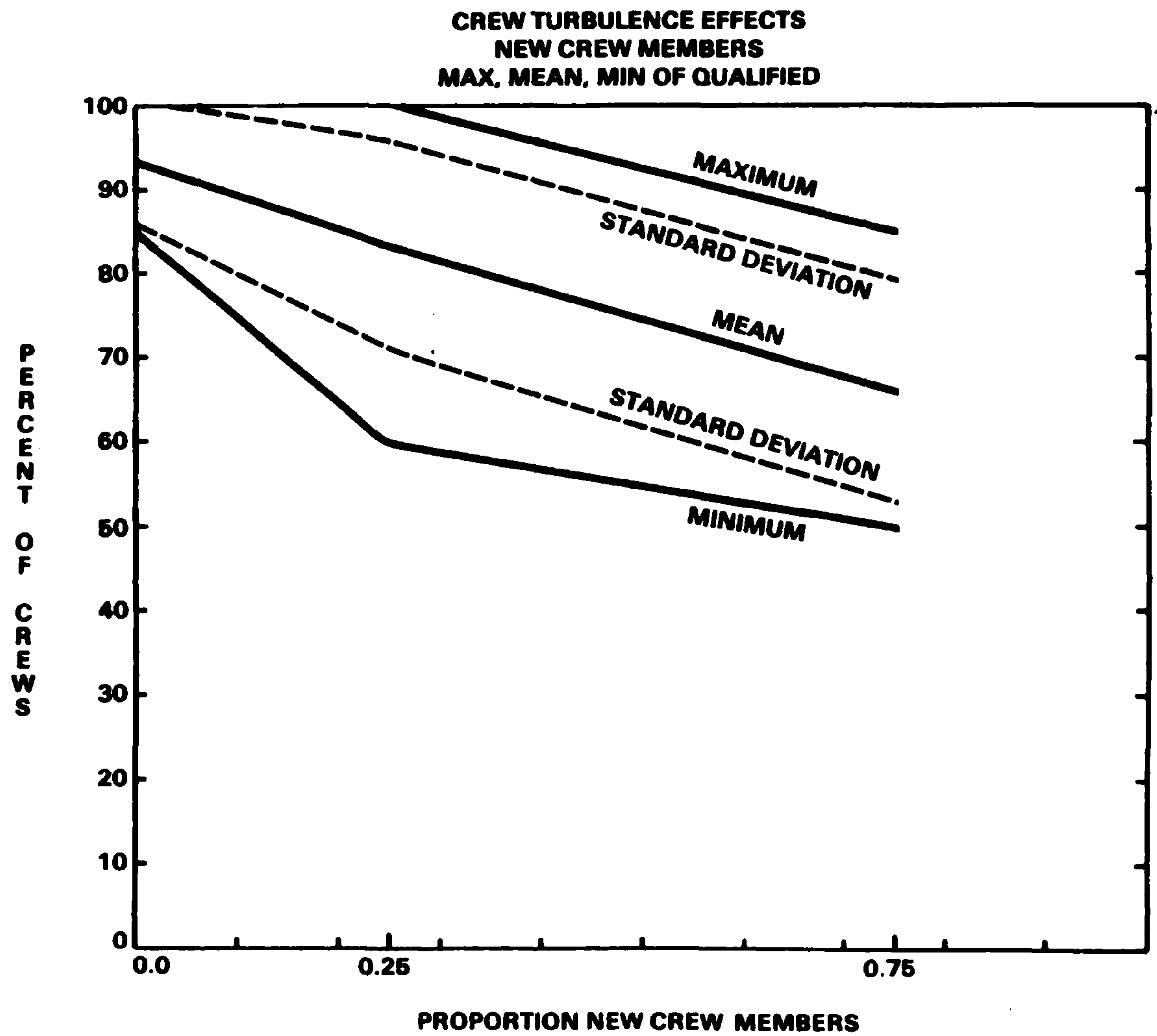


Figure A-10. Effect of Crew Turbulence

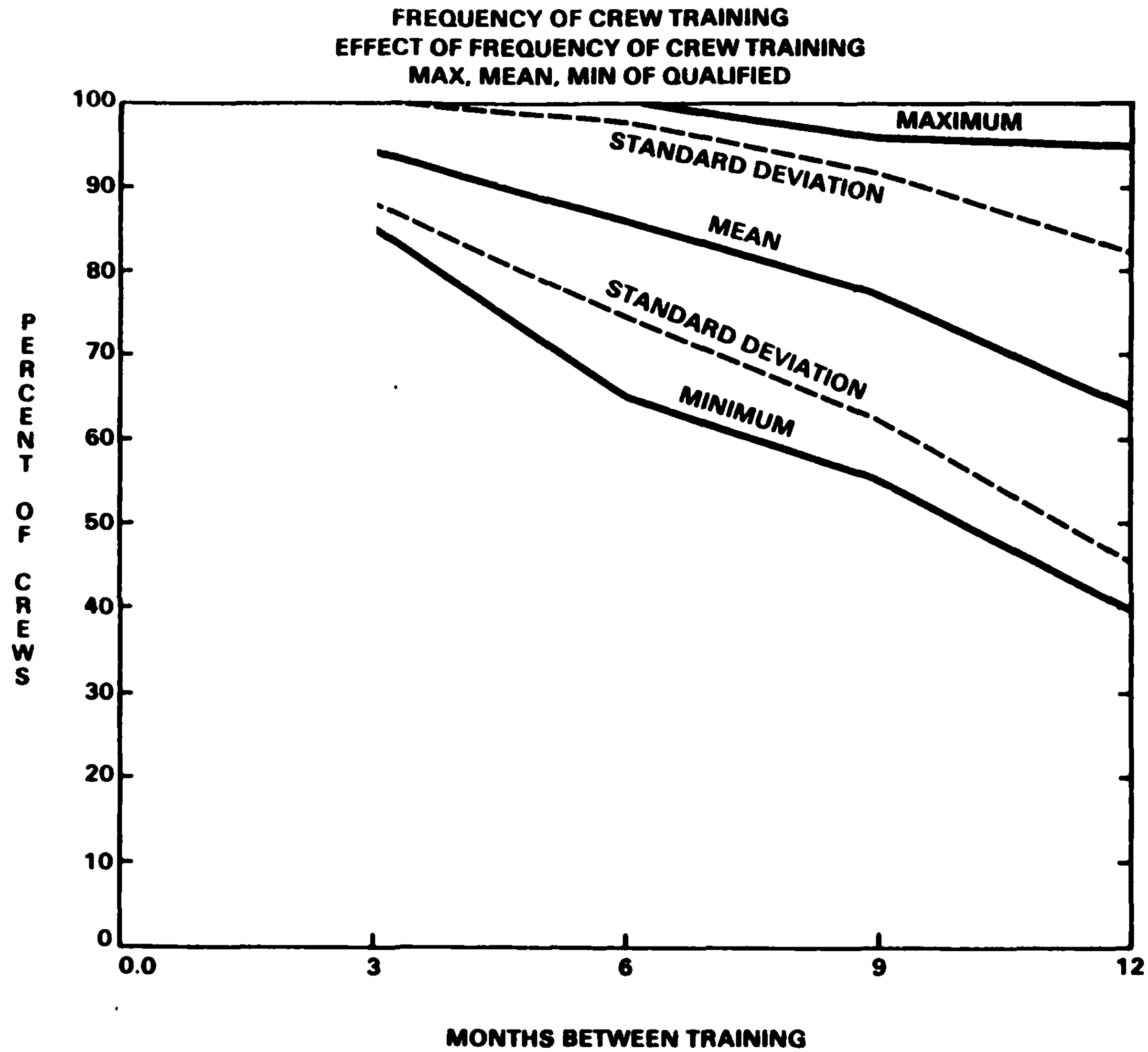


Figure A-11. Effect of Frequency of Crew Training (First Qualification)

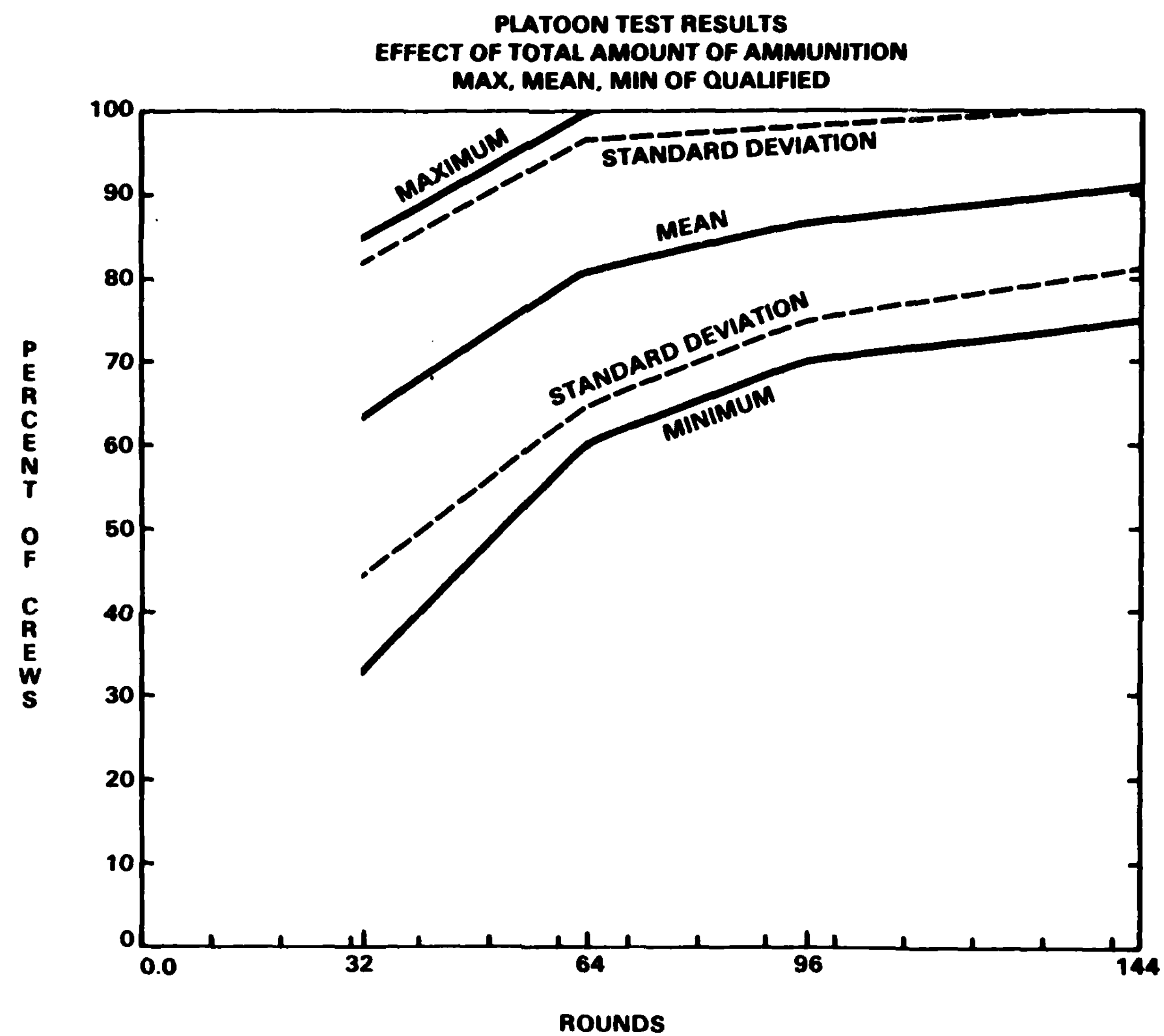


Figure A-12. Platoon Qualification as a Function of Full Caliber Rounds

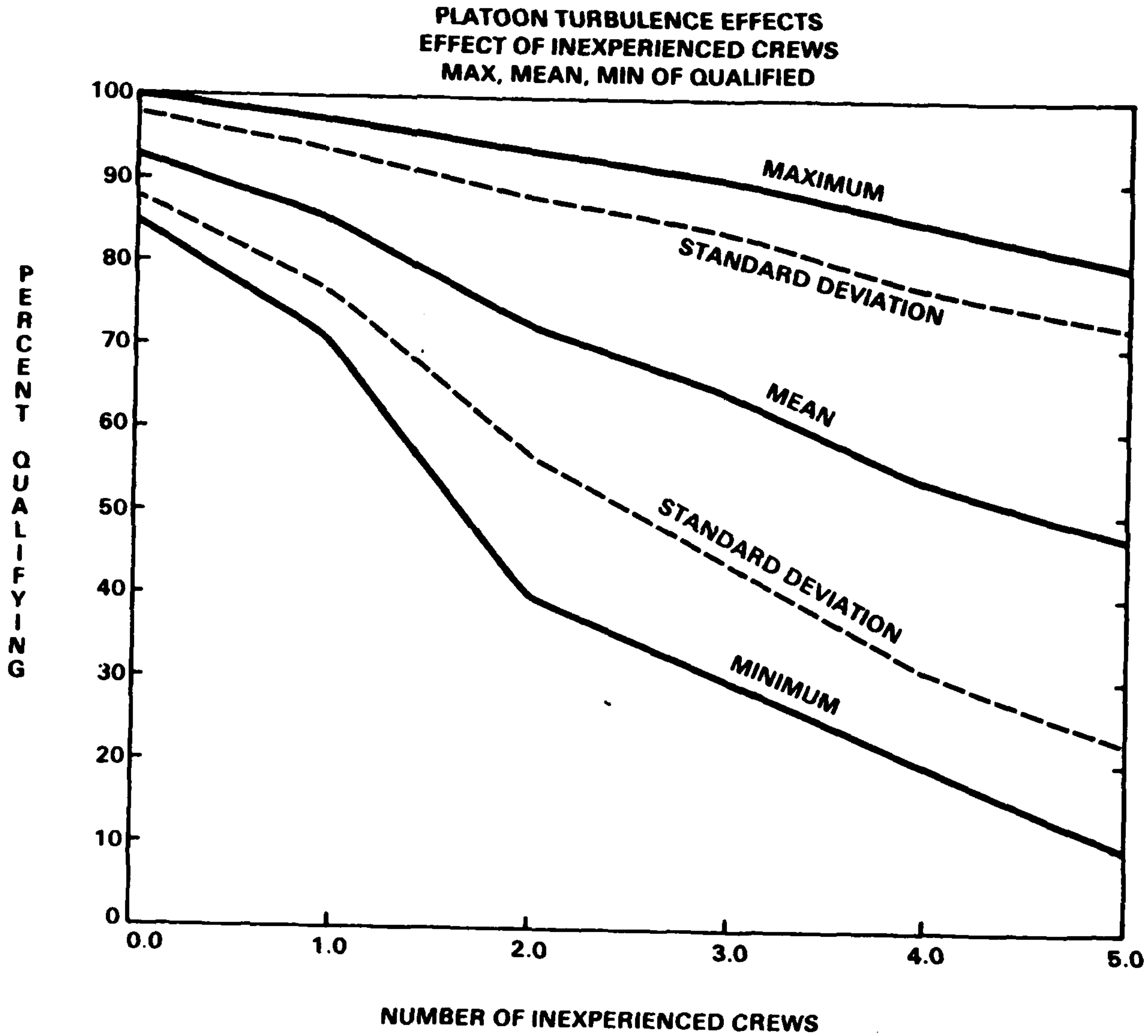


Figure A-13. Turbulence Effects on Platoons

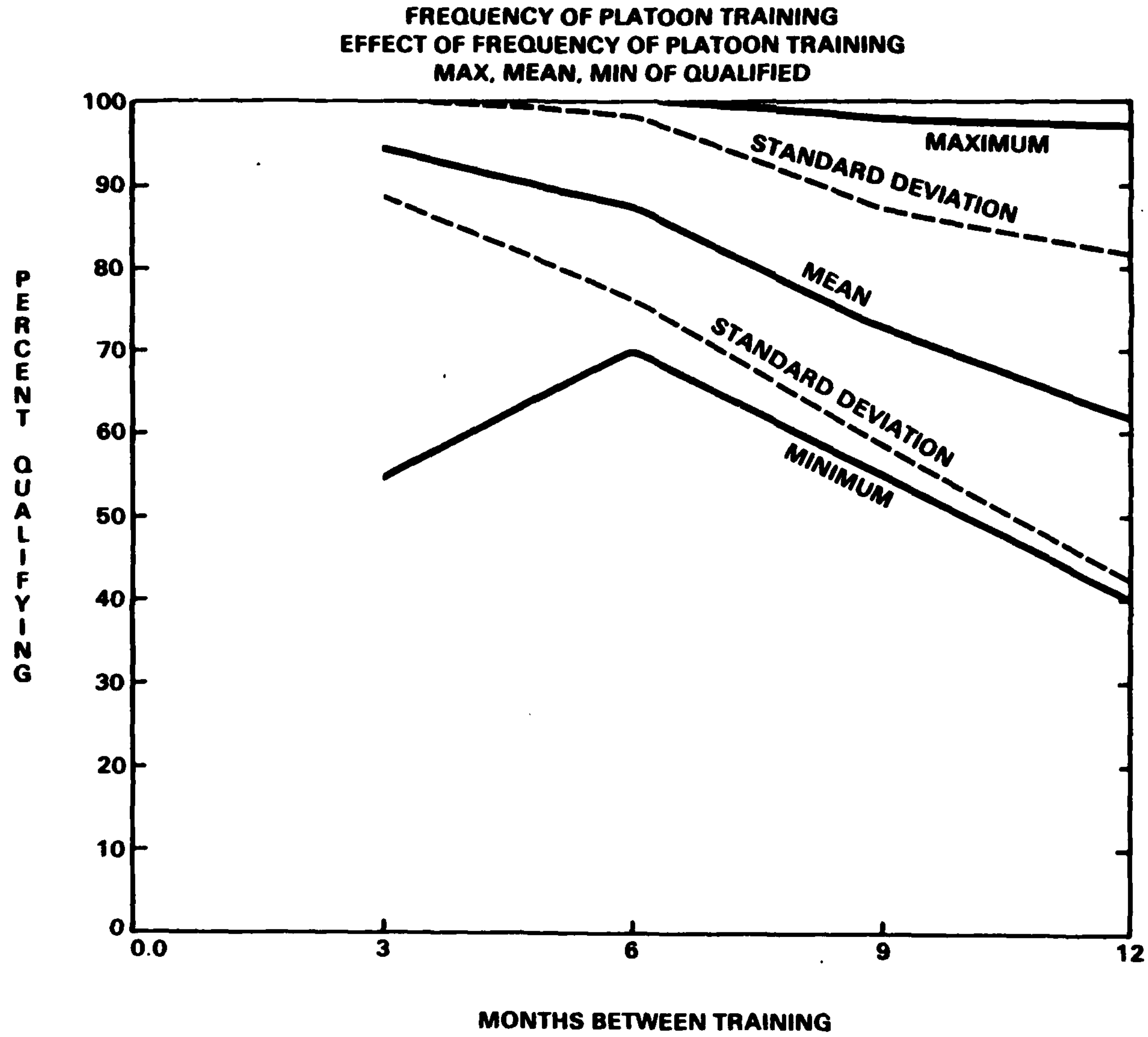


Figure A-14. Effect of Frequency of Training on Platoons

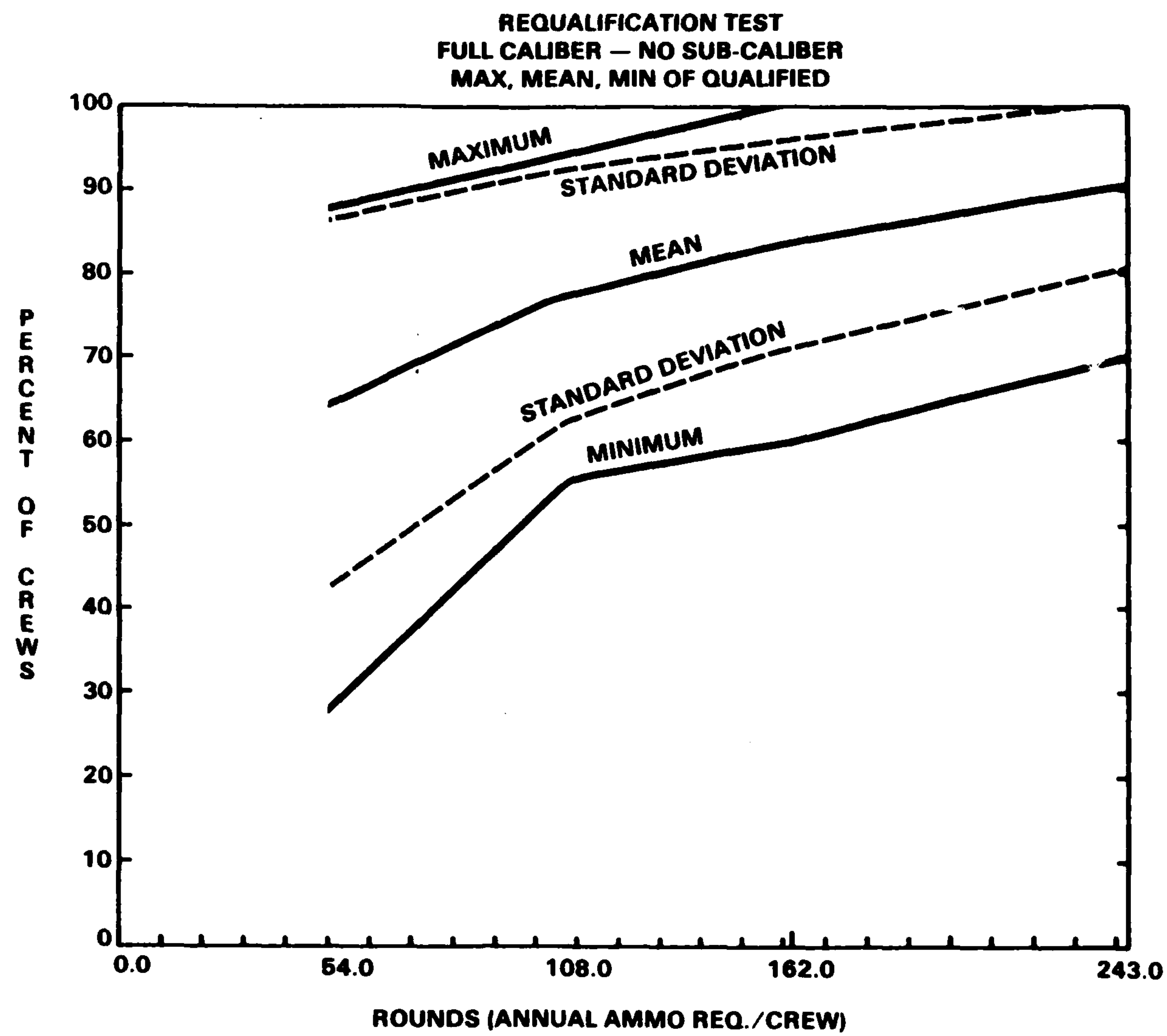


Figure A-15. Effect of Full Caliber Rounds on Crew Qualification (Requalification)

U = proportion of unqualified crews;

R = the average number of reshoots needed by a crew to qualify after it fails its first attempt;

A_F = basic allocation of full caliber ammunition.

This equation was used in the development of the data shown in Figures A-16, A-17, and A-18 for a reduction in the basic allocation of full caliber ammunition and no substituion of subcaliber. The three figures differ in the estimate of the number of retries needed before a crew finally qualifies after failing in its first attempt. All three figures show a continued reduction in the total amount of ammunition required as the initial allocation to each crew is reduced. Figure A-19 shows the same result with the substitution of subcaliber for full caliber ammunition. Platoon results are shown in Figure A-20 for full caliber and in Figure A-21 for subcaliber substitutions.

These results are based on subjective estimates of the respondents to the questionnaire. It is necessary to collect the hard data suggested in the test plan to validate the conclusions reached on the basis of the analysis presented in this report.

D. METHODOLOGY FOR ASSESSMENT OF FACTORS INFLUENCING AMMUNITION REQUIREMENTS

This paragraph offers suggestions for analysis of the data that might be collected from a test. A brief statement is provided on the type of descriptive statistics and data organization required, as well as an overview of inferential statistics. The sample in the proposed test will consist of the total population of 210 USMC tank crews. These crews are comprised of individuals with varying degrees of military experience. The 210 tank crews are organized into 36 platoons of five tanks each, 12 company command elements of two tanks each, and three battalion command elements of two tanks each. Ammunition allocations can range from the current full caliber allocation to as low as 1/3 the current full caliber

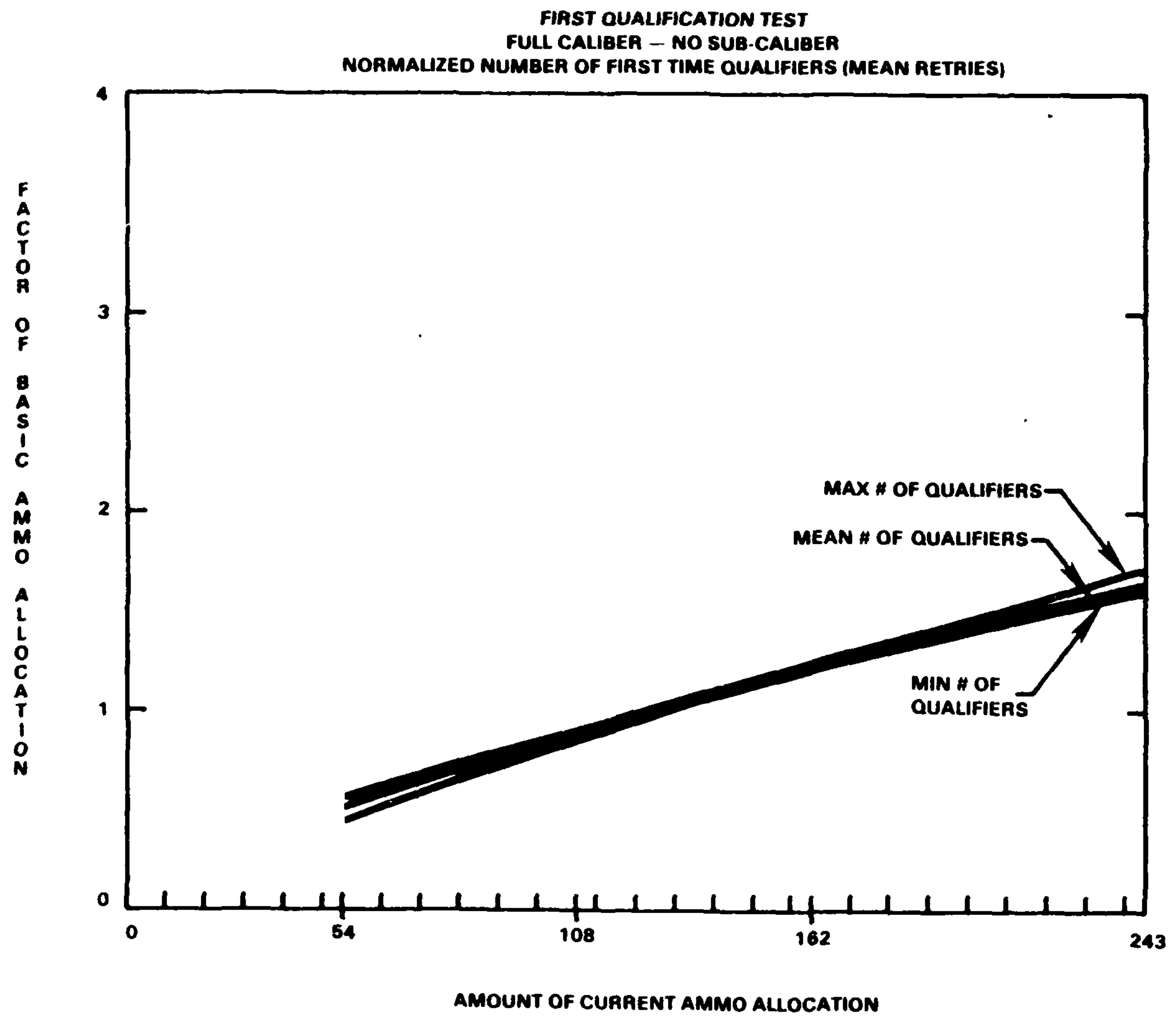


Figure A-16. Total Ammunition Requirement as a Function of Full Caliber (First Qualification, Mean Retries)

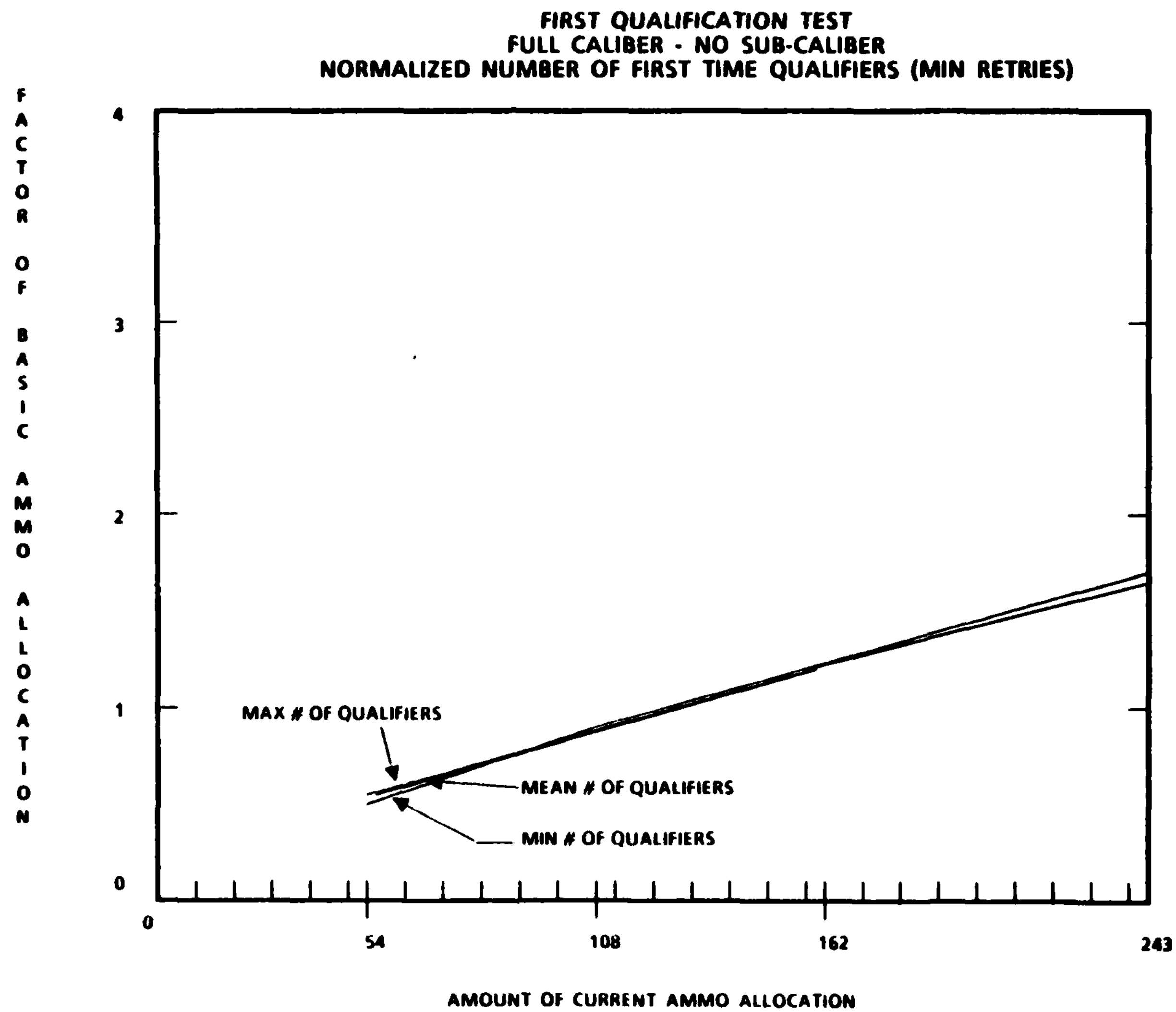


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Figure A-17. Total Ammunition as a Function of Full Caliber (First Qualification, Minimum Retries)

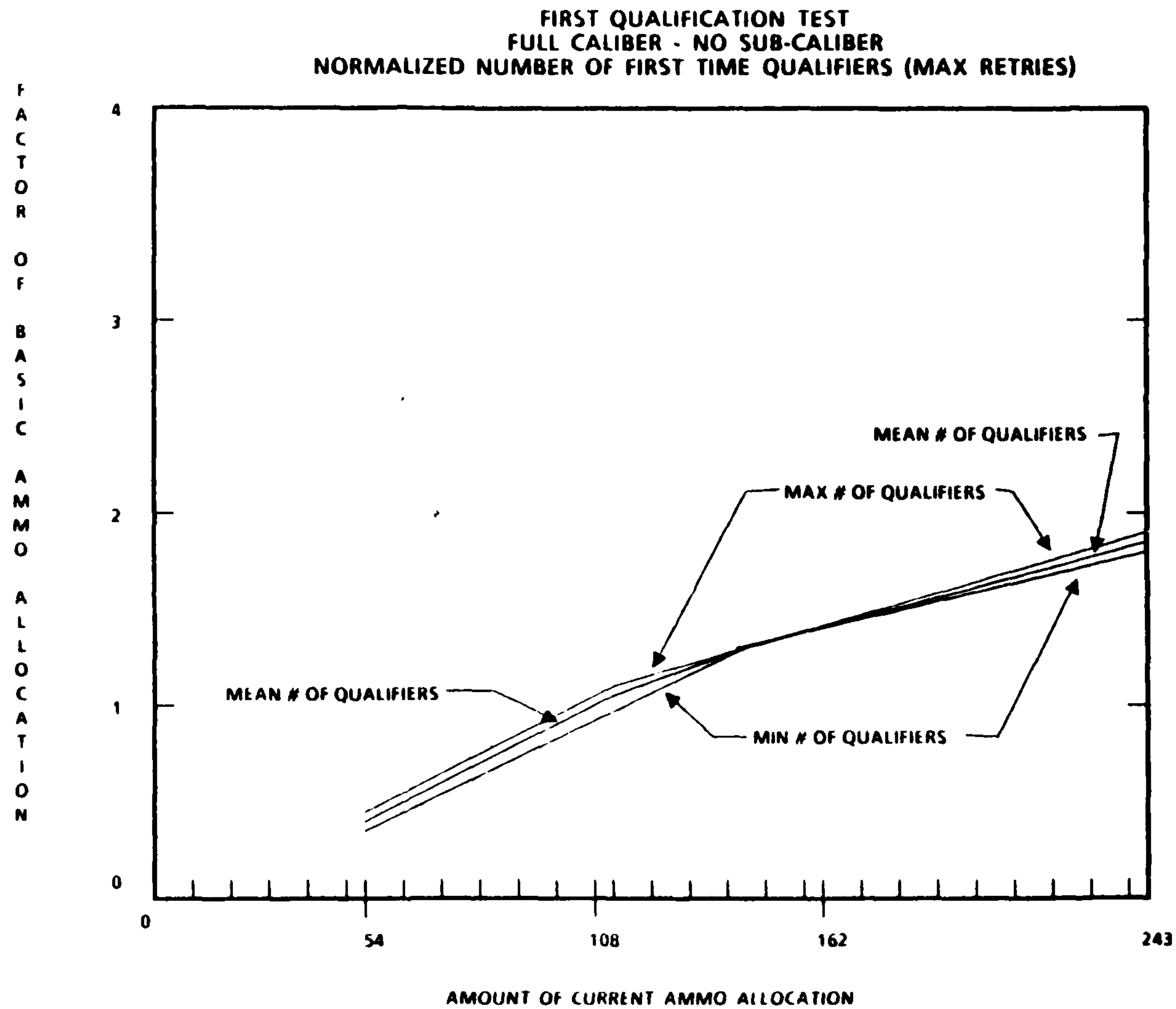

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Figure A-18. Total Ammunition as a Function of Full Caliber (First Qualification, Maximum Retries)

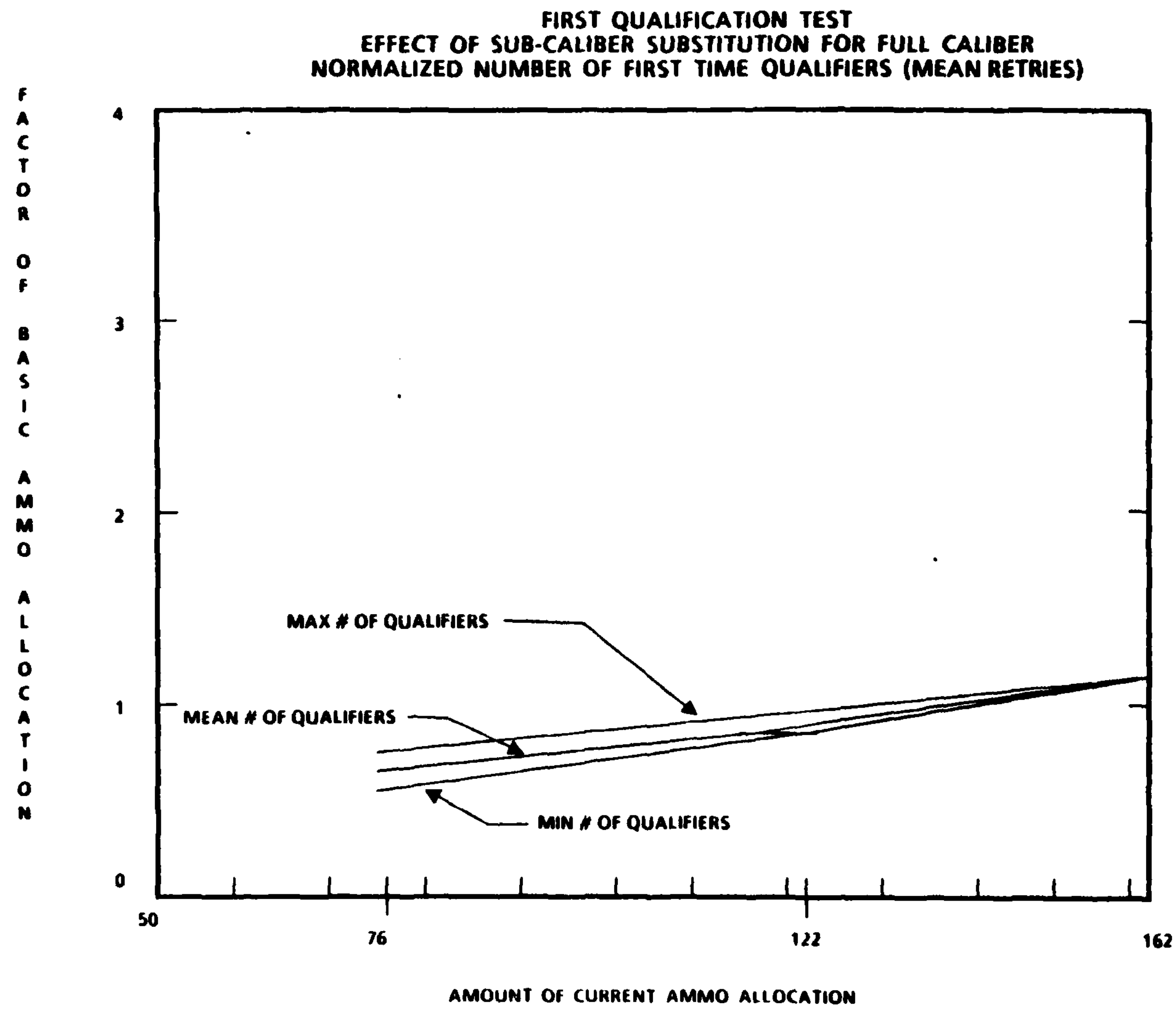

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Figure A-19. Crew Total Ammunition Allocation as a Function of Subcaliber Substitution (First Qualification, Mean Retries)

PLATOON TEST RESULTS
EFFECT OF TOTAL AMOUNT OF AMMO
NORMALIZED NUMBER OF FIRST TIME QUALIFIERS (MEAN RETRIES)

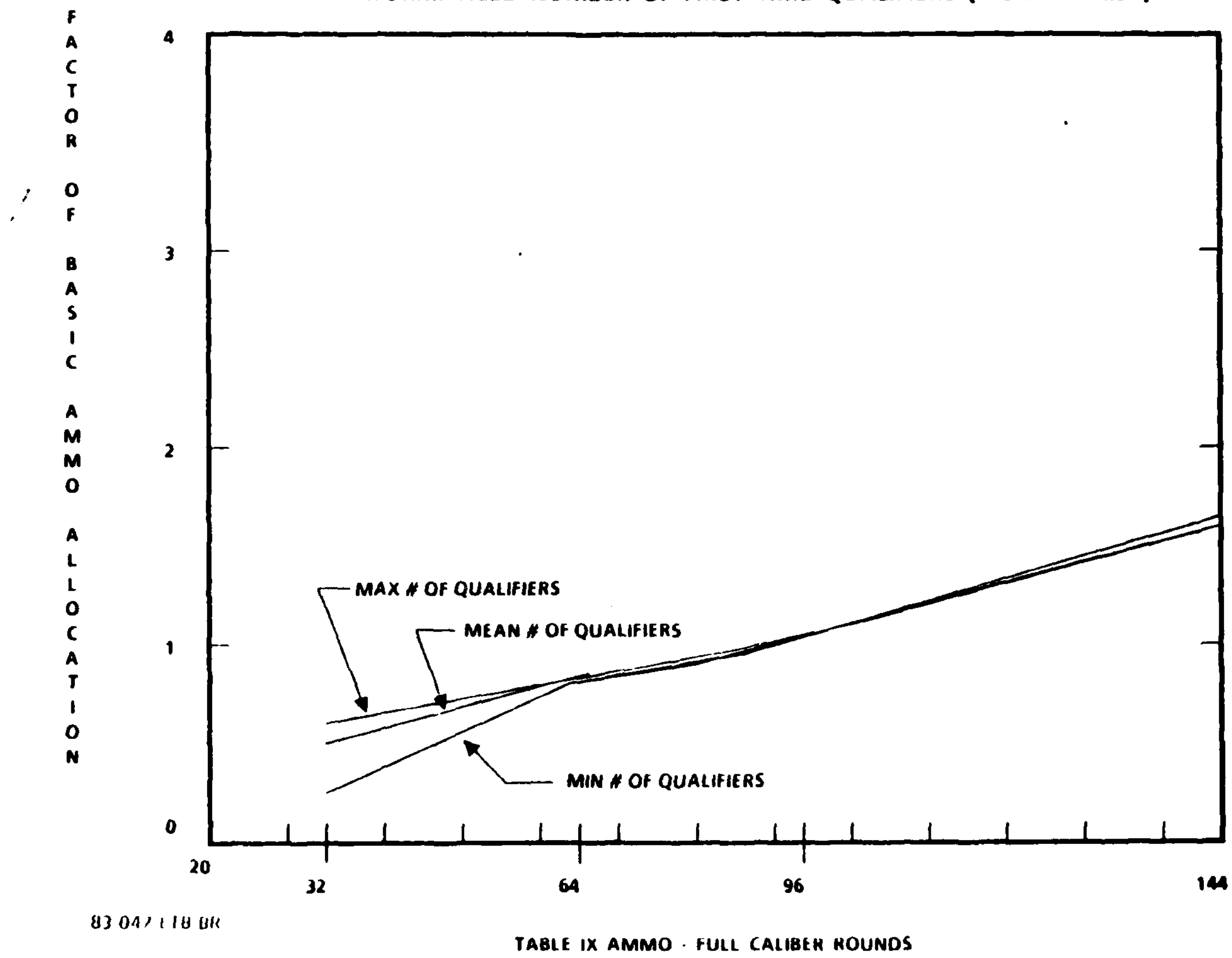


Figure A-20. Platoon Total Ammunition Requirement as a Function of Full Caliber (First Qualification, Mean Retries)

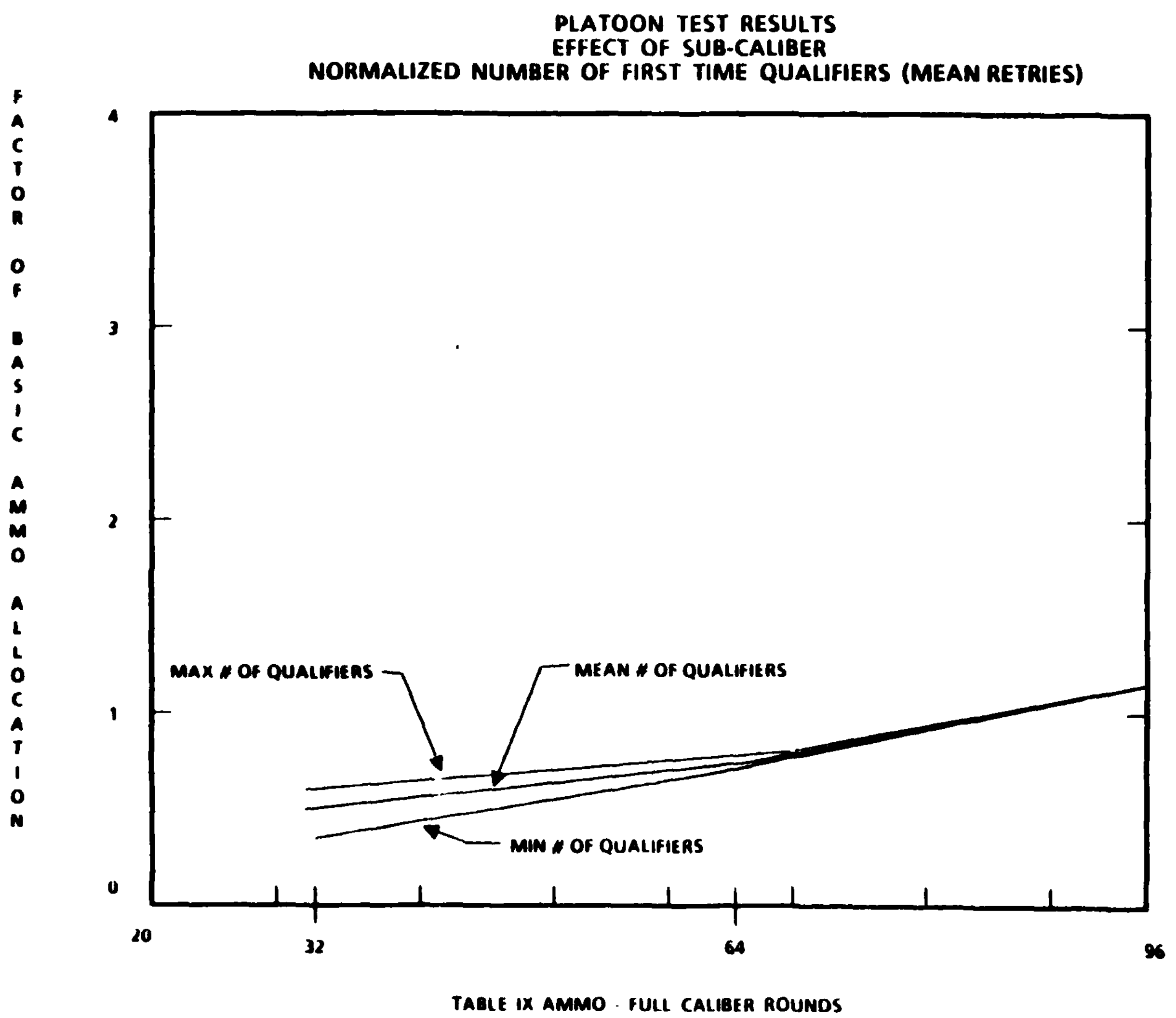


Figure A-21. Effect of Subcaliber on Platoon Total Ammunition Requirements (First Qualification, Mean Retries) allocation. Simulations can be used for zero to 90 percent of pre-table training. Individual tank crews require different training according to organization and mission, and whether they are in pre-deployment, post-deployment or afloat status. All of the above considerations must be taken into account in the analytic design of the test.

The data on performance will be obtained annually for one qualification test or test sequence (the latter for initial non-qualifiers) and for the total population of all 210 USMC tank crews. Measures to control extraneous variables (e.g., simulation, differences in training, and levels of crew experience) are not suggested due to the nature of present USMC qualification programs. Modification of qualifying procedures in order to reduce these confounding variables during the experimental condition could bias the results by making the experimental trials significantly different from prior test trials. Testing the entire population helps compensate for this design problem.

The Marine Corps will determine qualification standards and evaluation procedures including a data collection form. This form (i.e., the training profile) should facilitate the categorizing of raw data in the following manner:

(1) Ammunition Use and Proficiency

PLT.	CREW	% MAXIMUM SCORE	ANNUAL AMMO USED Live Rounds	SUB-Caliber	SIMULATION TYPE/# EVENTS
--	--	--	--		--

(2) Chronology of Events for Platoons

Platoon ________

EVENT	CREW	DATE
Table VI	2	11/23/83
Table IV (M55)	1	12/03/83
.	.	.
.	.	.
.	.	.

The remainder of this paragraph provides considerations for the selection of an appropriate inferential technique for data analysis. Ideally, a pilot study should be conducted to determine which methods are best suited to the sample and population. The need to make an early determination of Marine Corps ammunition requirements overrides this consideration, so the choice of method will have to be made on the basis of the data collected during the test.

The analysts responsible for processing the data may consider a number of inferential approaches, such as Factor Analysis, Analysis of Variance (ANOVA), Multiple-classification Analysis of Variance (MANOVA), Regression Analysis, etc. Several alternative approaches are discussed briefly below. The selection of an approach is a function of USMC R&D resources (hardware, software, data collection procedures, etc.) as well as the characteristics of the test itself. The Marine Corps, therefore, should decide which statistical tool will yield research results in a manner which best meets test objectives.

Factor Analysis manipulates a number of variables in order to ascertain underlying traits (factors) identified by a collection of intercorrelations. Factor Analysis is frequently applied in the field of test construction whereby clusters of measures (tests), containing high correlations with a factor, are associated with that factor. Factor Analysis may, therefore, be less applicable for the proposed test.

ANOVA and MANOVA test for mean differences between groups by computing the variances for these groups. Scores are artifically combined into a total group and comparisons are made between the sub-groups and the total group. In this case, the groups might reflect mission and organization. MANOVA should be considered for the present study. It is highly sensitive to subtle interactions among variables.

Multiple Regression Analysis is based upon the requirements that: (1) the variances in x values for any given y should be comparable, and (2) the spread of y scores for individually considered values of x should be equal. Regression Analysis also assumes that the values of y for given values of x are distributed normally. When the above assumptions underlying the use of Regression Analysis have been met, this treatment is highly sensitive to subtle interactions such as might be found between mission and turbulance. Communality Analysis, a system of Regression Analysis whereby residuals are subtracted in the Regression equation, may also be considered as a possible research tool. This might enable, for example, isolation of the effect of sub-caliber substitution.

Based on the study group's understanding of the test objective and data variables, it is recommended that MANOVA be considered the preferred alternative for the analysis tool for the proposed test. There are two principal reasons: first, the test design and the statistical assumptions requisite to MANOVA are compatible; in addition, the inferential capabilities of this technique would enable the analysis to focus on the role of full caliber ammunition.

ANNEX B

DEVELOPMENT OF THE INDIRECT-FIRE METHODOLOGY AND THE ANALYSIS OF QUESTIONNAIRES

The purpose of this annex is to display a methodology which relates the amount of training a Battery receives to the "proficiency" of that Battery. The approach used here is to construct two mathematical models of proficiency: The first model relates the training of individual battery elements - the Forward Observer (FO), the Fire Direction Center (FDC), and the Howitzer Gun Crew (GC) - to the individual proficiency of that element's crew. The second model integrates the individual element proficiencies to produce the overall Battery proficiency.

Both models state proficiency in terms of the Marine Corps Combat Readiness Evaluation System (MCCRES) standards. However, in the case of the element proficiency model, these standards are a matter of interpretation, whereas in the Battery proficiency model, the MCCRES standards are embedded in the mission analyses which constitute this model. Nevertheless, when either model predicts a proficiency of 85 percent at a particular time, it means that the element, or Battery, would score 85 percent, on the average, during a MCCRES evaluation given at that time.

This annex is divided into two parts. The first part develops the element proficiency model and fits it to subjective data. The second part develops the Battery proficiency model and fits it to subjective data linking elements' proficiency to Battery proficiency. Four tabs contain detailed information supporting the work on model development and fit.

PART I

THE ELEMENT PROFICIENCY MODEL

A. INTRODUCTION TO THE ELEMENT PROFICIENCY MODEL

The purpose of Part I is to describe a training model for crews manning crew-served weapons. The objective of this model is to predict the "combat readiness" of the crew at any desired instant of time. The concept of "combat readiness" or "proficiency" is taken with reference to the MCCRES standards. That is, when the model predicts a proficiency of 85 percent for a particular crew at a particular time, the crew would score 85 percent, on the average, during a MCCRES evaluation given at that time.

This model also incorporates two effects not present in typical learning models. These effects reflect two types of "unlearning". The first effect is that of "forgetting", which we interpret to produce a measurable decrease in proficiency due to a cessation of training. The second effect is that of "turbulence", which we interpret to produce a measurable decrease in proficiency due to the replacement of team-trained crew members by individually skilled but new members of the crew.

This model is based upon a fundamental assumption concerning the application of current learning theory to crews: namely, that a crew learning a complex procedural task will learn in the same fashion as a single person learning the same task. The primary support for this assumption comes from two papers concerning task complexity and task organization by Naylor and Briggs (see reference (1) - 1963 and (2) - 1965). We quote from reference (3) - 1968, an Industrial Psychology text by Blum and Naylor: (underline added for emphasis)

> "To the extent that task organization in an individual task represents a dimension identical to the team organization concept, data obtained from part versus whole research should prove to be a rich source of information for developing potential hypotheses about multi-man (team) tasks. Consider, for example, the Naylor and Briggs part-whole studies (1962-1963), which dealt with the advantages of whole task versus part task training for individuals as a function of task

> organization and complexity. One might view these studies as being analogous to a multi-man (team) training situation: <u>The training on individual task dimensions is similar to individual training of team members, and the whole task training of Naylor and Briggs was similar to "team" training in a multi-man task.</u> Naylor and Briggs manipulated task organizaton in their study by varying the amount of information which tied together two task dimensions. This definition of organization would certainly seem compatible to that typically used in a team situation of defining organization in terms of communication or information channels available between team members."

To complete this thought, we note that the recommendation of reference (3) is consistent with the recommendation of an earlier paper by Gagne (reference (4) - 1962) titled "Military Training and Principles of Learning". We continue to quote Blum and Naylor:

> "The 1963 Naylor and Briggs study indicated that for tasks of high organization, whole training appears to be most efficient regardless of task complexity; for tasks of relatively low (moderate) organizaton, whole training is best for tasks of low complexity but part training is best if the task is quite complex. Carrying this interaction over into the multi-man situation, it could therefore be hypothesized that for those tasks which are highly organized and which require a great deal of communication and cooperation between members, it would be best to employ team training. With tasks which only place low or moderate communication demands on team members, team training would be best if the subtasks are fairly simple, but individual training would be best if the subtasks are quite complex."

In this annex we make no recommendations concerning the organization or methods of training. We simply propose a model whose purpose is to relate the proficiency of a crew to the number of "training events" experienced by that crew. In this context, a "training event" will be some notional firings for example, one to two live-fire days) conducted under current procedures, and relatable to measurable performance in MCCRES tests or to subjective evaluation of measurable performance in MCCRES tests.

The remainder of this part is divided into four sections. The first is an overview of references we draw upon. The second presents "the learning model." The third describes forgetting, turbulence, and their effect on the Element Proficiency Model. The fourth provides the data analysis and some results. Let's first look over available reference material.

B. THE LITERATURE SURVEY ON LEARNING

As the BDM memorandum (reference (5) - 1982) points out, there is little help in the military training literature to support a learning model for crew training. Thus, we have concentrated on the open literature.

In the open literature our focus has been on industrial training. In particular, we found two volumes on Industrial Psychology which have a quantitative approach: Blum and Naylor (reference (3) - 1968), and McCormick and Tiffin (reference (6) - 1964). Both of these texts had informative chapters on training and had references from which we began our investigation.

From this initial set of references we tracked many papers on learning theory, some on forgetting (retention), and a few on team training. We will cite specific references in the technical sections to follow. We also found two texts on mathematical psychology: Coombs, Dawes and Tversky, (reference (7) - 1970), and Restle and Greeno (reference (8) - 1970). We used these mathematical text's chapters on learning theory to cross-check and embellish our original finds. As an aside, we discovered that a reasonable amount of training investigation was performed in the early sixties sponsored by the U.S. Naval Training Devices Center. We did not gather this work since we felt it would not add to our understanding of training models.

As a result of this tracing backwards, we reviewed the literature prior to 1974. In particular, we found several good review volumes: "Psychology: A Study of a Science" (reference (9) - 1959) and "Readings in Mathematical Psychology" (reference (10) - 1963). These volumes contain reprints of influential papers. Also, we found one excellent survey article: "Research and Theory on the Learning of Probabilities" (reference (11) - 1972).

At the same time we researched the Operation Reseach (ORSA) and the Management Science (TIMS) Journals. We were disappointed to find only three practical applications of learning theory. These were from reference (12) - 1961: "Analytical Methods for Determination of Training Device Requirements"; reference (13) - 1961: "A Model for Industrial Learning Cost" (a good one); and reference (14) - 1976: "Aggregate Planning with Learning Curve Productivity". References (13) and (14) are empirical studies that support the classical shape of learning curves, geometric/ exponential increasing curves up to an asymptote.

A quick survey of the mathematical literature turned up two quite useful books: reference (15) - 1955: "Stochastic Models of Learning", and reference (16) - 1977: "Urn Models and Their Application". The reference lists in these two volumes failed to add to our sources.

Finally, we scoured the Social Sciences Index from April 1974 to June 1982 under the topics of: learning, industrial psychology, mathematical models, employee training, occupational training, and statistical decisions. These led us to reference the following journals: Training and Development, American Psychologist, Experimental Psychology, American Journal of Psychology, Behavioral Research and Therapy, Applied Psychology, Mathematical Psychology, and Experimental Analysis of Behavior. We uncovered one good survey article, reference (17) - 1980: "Psychology of Learning, 1960-1980", but little else of direct applicability.

In our research we uncovered two significant papers from the Factory journal concerned with the industrial application of learning curves: reference (18) - 1943: "How to Figure Learning Time", and reference (19) - 1950: "Learning Curves Will Tell You Who's Worth Training and Who Isn't". These papers were direct, supported the classic learning curve shape, and showed an immediate useful applicaton.

The next section will derive the classic learning curves shape from the currently accepted discrete stochastic model of learning.

C. THE LEARNING MODEL

The development of quantitative relationships between the amount of "training" activity and the acquisition of "skill" seems to have taken place in three stages. There is the early "deterministic" models stage. There is the later "probabilistic" models stage. And finally the "polished probabilistic" models stage. Let's now discsuss these.

There is the early work by Thurstone on the acquisition of typing speed in 1919 (reference (20)) and his more general theoretical discussion in 1930 (reference (21)). These works represent "learning" by an accumula-tion-of-habits model which connects "practice" to "attainment". This work was generalized by Gulliksen in 1934 (reference (22)) who provided separate parameters for the effects of "reward" on a correct response and "punish-ment" on an incorrect response.

At the same time, the first books on learning were being published by Guthrie (reference (23) - 1931) and Skinner (reference (24) - 1930). However, the first major attempt at formulating a general quantitative theory of learning was by Hull (reference (25) - 1943) who formulated a deterministic "growth" model describing the "growth" of habit and a corresponding "decay" of inhibition. We quote from W.K. Estes in reference (9):

> "Learning was to be represented by the growth and decay of two hypothetical entities, habit strength and inhi-bition. Specifically, it was assumed that for any fixed set of conditions, each reinforcement produces a definite, predictable increment in habit strength, the increments summating to an exponential growth curve over a series of trials, and that each response evoca-tion produces a definite, predictable increment in inhibition, the total amount of inhibition decaying as an exponential function of time following the response. A simple growth and decay model was clearly inadequate, however, to cope with the observed variability of behavior, and Hull supplemented it by postulating an autonomous oscillatory process which permitted the effective excitatory strength of a response to vary from moment to moment around the mean value determined by such independent variables as preceding reinforce-ments."

The "natural" second stage of the development of learning theory recast the theory into probabilistic form. There is the work of Mueller (reference (26) - 1950) who used a Poisson model to measure conditioning. There is the work of Miller and Frick in (reference (27) - 1949) applying information theory to operant behavior. But the two most lasting ideas in the probabilistic models of learning theory orginated from 1) a sequence of papers and a book by Bush and Mosteller starting in reference (28) -1951, reference (29) - 1953, and (the book) reference (15) - 1955; and 2) a paper by Estes (reference (30) - 1950), following on papers by Guthrie (reference (31) - 1946) and by Guttman and Estes (reference (32) - 1949) which indicated how probabilty is needed to explain the variation in learning between individuals. Estes followed his 1950 paper by joint applied work in references (33) and (34), both in 1954. Both the developments of Estes and Bush/Mosteller view the underlying nature of learning the same way. They differ only in their emphasis as to what is crucial in making the structure work.

A compact description of this common structure can be found in reference (7):

> "The process is conceived of as a sequence of discrete trials. Each trial consists of the presentation of a stimulus situation to which the subject responds by selecting one from a set of alternative responses in accordance with an associated set of probabilities; the response is followed by an outcome, which may induce changes in the probability values before the next trial."

The Bush and Mosteller approach has come to be known as the Operator Model while the Estes approach has come to be known as the State Model. Both models, in spite of this difference, yield the same final quantitative form of the expected skill attainment.

The reason they yield the same quantitative form is that they are both "replacement" models in contrast to the early works which were "accumulation" models. In accumulation models, learning is modeled as increasing (to infinity) accumulation of good habits. Replacement models take the view that the nature of learning is to replace wrong tendencies with right tendencies, replace bad habits with good habits.

Estes formulation built this exchange about the stimulus-response association theory of Guthrie (reference (31) - 1946) and has now come to be known as stimulus sampling theory. In this formulation, and we quote reference (7) again,

> "Stimuli are conceived as a set of elements or components, left undefined. Each stimulus element is assumed to be associated with exactly one response. The presence (effectiveness) of a stimulus element on a trial affects the probability of the associated response being selected on that trial. A reinforcing event is one that affects the associations between stimulus components and responses."

The Bush and Mosteller approach makes no such "causal" connections between concepts such as stimulus, response, association, and reinforcement. Rather, they specify certain analytic assumptions concerning 1) the Markov property, that is, the probability of any response on the next trial depends only on its probability at the preceding trial and the event that occurred: and 2) the independence condition of combining "response" classes, that is the partitioning into discrete alternatives is not unique and the experimenter can define them either before or after the experiment and achieve the same probabilities.

On the whole, we can best demonstrate the "linear stochastic theory" by using an "urn model" description. An "urn model" description can be found in reference (8) which reference (16) borrows. For our application we can describe the connection between practice and skill acquisition as follows (based on reference (16)). A subject (crew) in a learning situation is regarded as being associated with an urn containing gold and red balls. A subject whose urn contains all gold balls can be interpreted as 100 percent proficient.

According to the "replacement" idea, the total number of balls in the subject's urn is always fixed, say at m balls. The simple replacement learning process consists of selecting some fixed number of balls, say k, from the subject's urn at random and replacing them with all gold balls (if learning is imperfect, the replacement could come from an infinite store of mixed gold and red balls from which k are removed at random).

We can describe the expected contents of the urn after any training event as follows. Let G_n and R_n be the number of gold and red balls in the urn respectively ($G_n + R_n = m$), at stage n. Then after the n+1st training event we have the following expected value:

$$E[G_{n+1} \mid G_n] = G_n (1 - \frac{k}{m}) + k, \tag{1}$$

so that

$$E[G_{n+1}] = E[G_n](1 - \frac{k}{m}) + k. \tag{2}$$

That is, with G_n gold balls in the urn, we expect to remove kG_n/m gold balls at stage n+1, and then add back k gold balls to the urn at stage n+1.

Let

$$P_n = \frac{G_n}{M} = \text{ probability of a correct response (skill level)}$$

$$\Theta = \frac{k}{m} = \text{ the proportion of balls sampled from the urn during training.}$$

Then equation (1) translates into

$$E[P_{n+1} \mid P_n] = P_n(1-\Theta) + \Theta, \tag{3}$$

which working back to P_0 yields

$$E[P_{n+1}] = (P_0 - 1)(1-\Theta)^{n+1} + 1. \tag{4}$$

Thus, as training continues, the subject's proficiency goes to unity. Equations (2) and (3) are of linear form. This form lends itself to the name Linear Stochastic Learning Theory.

About the same time as development of the linear models of Estes and Bush/Mosteller, there were also introduced some "non-linear" models. For example see Luce's β model (reference (35) -1959) and Audley-Jonckheere (references (36) - 1956, (37) -1957, and (38) - 1958). A comparison of the "goodness-of-fit" of the linear model with these non-linear models can be found in Restle and Greeno's book (reference (8)). The comparisons there show a distinctly better performance overall for the linear models.

The final stage of evolution of linear stochastic learning theory was inspired by Estes (reference (39) - 1959, already cited in reference (9)) when he considered the stimulus sampling theory in the special case of one stimulus component. This development is important because the underlying psychological assumptions lend themselves to the application of linear stochastic learning theory to groups of individuals. This "small-element" or "all-or-none" model was developed by Bower in 1961 and 1962 (references (40) and (41)), with favorable results for "paired-associate" memorizing, and then by Suppes and Ginsberg (reference (42) - 1963) and Atkinson and Crother (reference (43) - 1964) with less favorable results. These less favorable applications, however, seem to deal with multiple stimulus items.

The "all-or-none" model, in its simplest form can be described as follows. A single stimulus element is in one of two conditioning states - either it is trained (T) or untrained ($\bar{T}$). On any reinforced trial, an element in state T has probability c of transiting to state $\bar{T}$. The value c is trial-independent and once in state T one stays in state T. Finally, and as a new idea, the probability of observing a correct response has value 1 in state T while it has value g (guessing probability) in state $\bar{T}$. This theory separates the state of the learner from our observations of the state of the learner, and thus falls into the mainstream of the state/observable approach in scientific enquiry.

From this simple model description, the probability of a correct response on the nth trial, P_n , can be written as

$$P_n = Pr(T_n) + g \cdot Pr\,(\bar{T}_n) \tag{5}$$

where T_n represents being in the trained state at the nth trial and $\bar{T}_n$ the untrained state. Equation (5) holds because in state T the correct response occurs with probability one, while in state $\bar{T}$ the correct response occurs with probability g. Furthermore, assuming $P(\bar{T}_0) = 1$, the independence assumption for learning implies,

$$Pr(T_n) = (1-c)^n,$$

and (6)

$$Pr(\bar{T}_n) = 1-Pr(T_n)\ .$$

Thus, equations (5) and (6) imply

$$P_n = 1-(1-g)(1-c)^n, \quad (7)$$

which is identical to equation (4) in form.

Although equation (4) and (7) have the same form, there are differences in the two theories which occur when we calculate variances. These occur because an incorrect response in the original linear model is independent from trial to trial, whereas in the all-or-none "linear" model such incorrect responses are highly dependent. However, these issues will not concern us here, as we are satisfied by the linear learning form.

Nevertheless, with a view to our application, we can interpret (4) as a "mass action" effect of (7). To see this, regard all-or-none learning of one trait to be represented as an "urn model" with one ball in the urn. It is either a red ball (untrained trait) or a gold ball (a trained trait). Each training event has probability c of changing the current ball to a gold one (even if it is already gold) and each measurement of proficiency allows "mistaking" a red ball for a gold one with probability g. This "urn model" will duplicate equation (7).

Now picture a training situation to consist of m traits to be trained, say of equal difficulty so that c is the same for each, (this is to get around the item selection criticism of Postman (reference (44) - 1968) and Underwood and Keppel (reference (45) - 1962)). If the training event trains all traits simultaneously, then some random fraction of the m balls in the urn are sampled for change, with the average fraction being c. Some expected transition equation such as equation (2) applies.

However when measuring "proficiency", the measure must include g, say the same g for each trait. This would lead to a measure

$$P_n = G_n/m + g \cdot (1-G_n/m) = (G_n/m)(1-g) + g.$$

That is, it is as if the measure of proficiency could be set equal to the number of gold balls in the urn if the urn were seeded with some initial number of gold balls not representing traits, but placed there to account for the measurement deception of a correct-looking response from an untrained trait. Specifically,

$$E(P_n) = E\left(\frac{G_n}{m}\right)(1-g) + g,$$

$$= 1 + (1-\theta)^n (1-\frac{Go}{m})(1-g) + g, \qquad (8)$$

$$= 1 + (1-\theta)^n [(1-\frac{Go}{m})(1-g)],$$

and G_o/m could be corrected to $(G_o + g_o)/(m + g_o)$, where g_o depends on g. This method of dealing with multiple stimulus elements might satisfy the criticism of reference (43).

Thus, we propose to use a training model of the form of equation (3). It will take the general form that on any training trial

$$P_n = P_{n+1}(1-T) + T \qquad (9)$$

Where T is a random variable with values in [0,1] and a known mean value Θ. Applying the expected value operator will thus lead to equation (3).

Our point is that it is useful to adopt the view that the task of a crew can be interpreted as a set of traits or performance habits which are aquired through practice. Each "atomic" trait is some simple association learned by one individual in response to an elicitation by a previous action in a procedural task generated by himself or by some other member of the crew. Then if we accept the "all-or-none" model of the simple trait as it leads to a linear theory, then we can also accept the linear theory in the aggregate, and can apply the linear stochastic theory to the acquisition of proficiency in a crew activity.

D. FORGETTING, TURNOVER, AND THE CREW LEARNING MODEL

The previous section has discussed the general form of the learning model we propose for crews. However, this model is not completely adequate in that it fails to predict all "paired-associate learning" data (a learning situation in which a pair of items is matched in memory). According to reference (7) there may be another psychological process influencing the performance - a forgetting process. For crew performance, the same effect may be produced by personnel turnover since that is another mechanism by which learning is lost. We need a mechanism permitting a transition from a "higher state for training" to a "lower state of training".

The results of study concerning "forgetting" is not nearly as strong as the results of learning. One early model of forgetting derives from the work of Peterson and Peterson (reference (46) - 1959) in which it was observed that there can be appreciable forgetting over a short period of time. In combination with the all-or-none model, we might presume a long-term memory (permanently trained) and a short-term memory (temporarily trained) from which state the subject may transition back to the untrained state. Atkinson and Crothers (reference (45) - 1964) proposed this type of model. This model combines the learning and forgetting processes, each of which is all or none.

Atkinson and Crothers found that this "two-state" model was not as satisfactory as a "three-state" model in which the unlearned state is distinguished from the "forgotten" state. Intuitively, it is easier to recover an association from the forgotten state than it is to create an association from the unlearned state. There are also more complicated models ("four-state" by Bernbach in reference (47) - 1965), however, for our purposes we would like to keep the model simple, and if we allow that turnover in crews is the major element in "unlearning", then a transition to a single unlearned state is not unreasonable.

Furthermore, much of the theory concerning forgetting is based on paired associate memorizing situations. In our application we are concerned with the learning of procedural tasks, and there is no a priori reason that the retention of paired-associates, the retention of motor-skills, and the retention of procedural links in motor-skills behave the same way. However, in a paper by Fleishman and Parker (reference (46) - 1962), concerning retention and relearning of perceptual motor skills (tracking in an airborne radar intercept mission), it was found that retention is quite high even for no-practice periods of up to 24 months. What small losses did occur were recovered in the first few minutes of relearning. This seems to indicate that this task recovery was more rapid for learning from an unlearned state and is similar, in that respect, to paired-associate learning.

On the other hand, a paper by Schendel and Hagman (reference (49) 1982) is dedicated to procedural skills. As they define:

> "Procedural tasks generally involve series of discrete motor responses... The responses themselves are easy to execute; it is deciding what responses to make and in what sequence that poses the main problem for the learner... Procedural skills appear highly susceptible to the effects of forgetting, especially when contrasted with continuous control skills like tracking (e.g. Fleishman and Parker 1962). For example Adams and Hufford (reference (50) - 1962) investigating the effects of whole- and part-task training on the retention of a complex bomb-toss maneuver, found a 95 percent loss of procedural response proficiency over a 10-month retention interval, but found no practically important effect on the retention of continuous flight control responses."

The Schendel and Hagman study was designed to assess different approaches to deter forgetting after initial training. They tested three methods:

(1) No training during the retention period (baseline),

(2) One refresher midway through the retention period,

(3) Overtraining initially. This study used the disassembly/assembly of the M60 machine gun (35 distinct procedures) as the proficiency test.

Each subject was trained to an errorless performance (with the third group overtrained). From the point of view of retention, the baseline group exhibited about 6.2 errors after 8 weeks, the overtrained group 2.2 errors. The midway retraining group exhibited about 2.7 errors after 8 weeks but 5.3 errors during the first trial of the midway retraining period after 4 weeks. We conclude that a reasonable amount of forgetting occurs, and that it is more rapid in the beginning (5.3 errors after 4 weeks) than later on (6.2 errors after 8 weeks for a difference of .9

errors due to the latter 4 weeks of no training ignoring the inherent variability between groups).

The Schendel and Hagman paper also shows that recovery is not substantially more rapid than initial learning. Concerning the retraining after 8 weeks, the control group required 2.43 trials per subject, on the average, to recover to flawless performance (after 6.2 errors on the first retraining trial) with a total of 5.14 trials per subject during the entire experiment. This indicates that initial learning consumed 2.71 trials. Thus, in the case of a procedural task, there seems to be only a speculative distinction between an "unlearned" state and a "forgotten" state.

We conclude, then, that a two-state model combining learning and unlearning, each of which is all-or-none (as proposed by Atkinson and Crothers, reference (45), is not unreasonable for procedural tasks involving one individual. For crews, with turnover, it seems even more reasonable (this is probably not the case in other team training situations in which one member helps another at a single task such as jigsaw puzzle building as reported by Wiest, Porter, and Ghiselli in reference (51) - 1961).

The following paragraphs develop this idea using the same "urn" model with gold and red balls introduced in the previous section. Just as we increased the gold balls during a learning event, we must also increase the red balls during an unlearning event and build those together into the same model.

To do this, consider the condition of a crew during any week. It begins the week at some proficiency level and during the week there is some training and perhaps also some "untraining". We wish to estimate the proficiency of the crew after some N weeks. Let's see how we would start with N=1 weeks.

Let's assume that "untraining" should be evaluated before training (when a crew member is replaced during a week in which a "training event" occurs, the event is delayed until the new member arrives). For our application "unlearning" is of two sorts -forgetting and turnover. Let's incorporate forgetting into turnover when it occurs so that "untraining" during a week is called "forgetting" unless there is turnover, in which case the untraining is called "turnover". Anticipating "turnover" to represent more untraining than "forgetting", then the amount of untraining during any week depends on whether or not a crew member is lost in that week. This depends somehow on the "turnover rate".

Define $P(0)$ to be the crew proficiency at the beginning of week number 1, and assume no training event occurs during that week. Then the proficiency at the end of week 1, $P(1)$, will be less than $P(0)$ on the average. Following equation (3) in form

$$E[P(1)|P(0)] = P(0)(1-u) \tag{10}$$

where u is a specified fraction of balls to be replaced and the replacement will be by red balls. Thus some random number of gold balls between 0 and u are removed from the urn, with the expected removal being $P(0) \cdot u$.

In our case, the value of u depends on whether the untraining event was a "forget" or a "turnover". We anticipate that the value of u associated with turnover will exceed that associated with forgetting. Thus we generalize equation (10) and let the random variable U_1 represent the fraction of balls drawn from the crew proficiency urn during week 1 (and replaced by red balls). We conclude that

$$E[P(1)|P(0),U_1] = P(0)(1-U_1). \tag{11}$$

We apply an analogous rationale when it comes to training events. Either a training event will take place or it will not. When it takes place equation (3) applies for some positive value of t, when it does not equation (3) again applies with t=0. If we can evaluate the "training event rate", then we might estimate how often each value applies. Thus, we establish the random variable T to represent the fraction of balls drawn from the crew proficiency urn during week 1 (and replaced by gold balls). We conclude that

$$E[P(1)|P(0),U_1,T_1] = P(0)(1-U_1)(1-T_1) + T_1, \tag{12}$$

and equation (12) represents our estimate of the average proficiency of the crew at the end of the first week (= the beginning of the second week) given the initial proficiency $P(0)$, and the realization of the random events of training and untraining (where we assume the effect of training, when it occurs, applies after the evaluation of degradation due to untraining).

Let's now generalize equations (12) to N weeks. We assume the Markov property will hold, that is, the proficiency at the ith week depends only on the proficiency at the i-1th week and the events occuring during the ith week, and not on any previous week's events or proficiencies. That is, equation (12) applies for each i :

$$E[P(i)|P(i-1),U_i,T_i] = P(i-1)(1-U_i)(1-T_i) + T_i, \qquad (13)$$

$$E[P(i)|U_i,T_i] = E[P(i-1)](1-U_i)(1-T_i) + T_i.$$

Following equation (13) we conclude that

$$\begin{aligned} E[P(N)|U_1 \ldots, U_N, T_1 \ldots, T_n] = E[P(0)] \sum_{i=1}^{N} (1-T_i)(1-U_i) &+ \\ T_1 \cdot \sum_{i=2}^{N} (1-T_i)(1-U_i) &+ \\ T_2 \cdot \sum_{i=3}^{N} (1-T_i)(1-U_i) &+ \qquad (14) \\ &\vdots \\ T_{N-1} \cdot ((1-T_N)(1-U_N) + T_N) & \end{aligned}$$

Now we need to average the occurrences of the U_i's and T_i's.

First, let's assume that the random variable U_i and T_i are independent of each other, so that the training and untraining processes are uncorrelated. Also, let's assume as a baseline that all the U_i's are independent and all the T_i's are independent. This implies that the personnel turnovers from one week to the next are independent (of course, strings of turnovers will occur at random), and that the occurrence of a training event during one week makes it no more nor no less likely of a training event during the next week (of course, strings of several weeks of successive training will occur at random). Then, the expected value operation propagates through equations (14) yielding:

$$E[P(N)] = E[P_0]\sum_{i=1}^{N}(1-E[T_i])(1-E[U_i]) +$$

$$E[T_1]\sum_{i=2}^{N}(1-E[T_i])(1-E[U_i]) + \qquad (15)$$

$$\vdots$$

$$+$$

$$E[T_N] .$$

Let's further assume that the occurrence of a training event or the occurrence of a turnover is no more likely in one week than it is in any other. That is, each week has the same probability as the next as the owner of a turnover, or as the owner of a training event. In this case we can regard such occurrences as Bernoulli trials with, say, probability α that a turnover occurs and, say, probability β that a training event occurs. Therefore we can define for all i:

$$\begin{aligned} &\Pr\{U_i = t\} = \alpha, \\ &\Pr\{U_i = f\} = (1-\alpha), \qquad (16) \\ &\Pr\{T_i = p\} = \beta, \\ &\Pr\{T_i = 0\} = 1-\beta, \end{aligned}$$

where t, f, and p are fixed fractions of balls to be removed from the crew proficiency urn. Using (16), (15) converts to

$$\begin{aligned} E[P(N)] &= E[P(0)]r^N + \beta pr^{N-1} + \ldots + \beta pr + \beta p \\ &= E[P(0)]r^N + \beta p(1-r^N)/(1-r) \qquad (17) \\ &= r^N(E[P(0)] - \frac{\beta p}{1-r}) + \frac{\beta p}{1-r} . \\ &(r = (1-\beta p)(1-\alpha t+(1-\alpha)f). \end{aligned}$$

Thus E[P(N)] grows or declines gracefully from E[P(0)] to $\beta p/(1-r)$ as $N\to\infty$. The value $\beta \rho/(1-r)$ represents the "steady-state" proficiency of the crew under training events which occur in a fraction β of all weeks and under turbulence which occur in a fraction α of all weeks.

We recognize that both training and turnover may occur in "lumps", and it is possible to use equation (14) to evaluate the effects on P(N) of correlated events. However, we are unable to do this at this time. Thus, we cannot make a theoretical judgment concerning the effect on team proficiency of overtraining as measured by the Schendel and Hagman paper.

Figures B-1a, b, and c display a "proficiency profile" of a particular crew over parameters: $p = .30$, $f = .01$, $t = .10$, several α 's and β's. The start value of $P(0)$ is taken as .7. Expectedly, during weeks in which training occurs, some increase in proficiency can be observed. During weeks in which turnover occurs, some decrease in proficiency can be observed. During weeks in which neither occurs, either no proficiency decrease is observed or a 1 percent proficiency decrease is observed. The upper bound, lower bound, and average depends on the training rate, the turnover rate, and chance (the ensemble average indicates the profile average over taken over all sample paths). Naturally, more training tends to increase the profile while more turnover tends to decrease the profile.

E. DATA ANALYSIS AND RESULTS OF THE ELEMENT PROFICIENCY MODEL

The analysis of the previous section has resulted in equation (17). This equation quantitatively describes the relationship between the rate of training and the rate of turbulence on the expected proficiency of any crew. This section applies this equation to the crews comprising an artillery battery - the FOs (as a group), the FDC, and the Gun Crew.

To perform this application, we need to establish the operating parameters for each crew as displayed in equations (16). We need to establish a value for p, a value for f, and a value for t. Then, by selecting various values for α and β, we can see the effect of the increase or decrease of training, and the effect of the increase or decrease in turnover, on the average proficiency of the individual element.

In fact, there are four applications of equation (17) which seem useful:

(1) Measure the gain in proficiency of a newly assembled crew ($\alpha=0$ no turnover, β at the normal live-fire training rate);

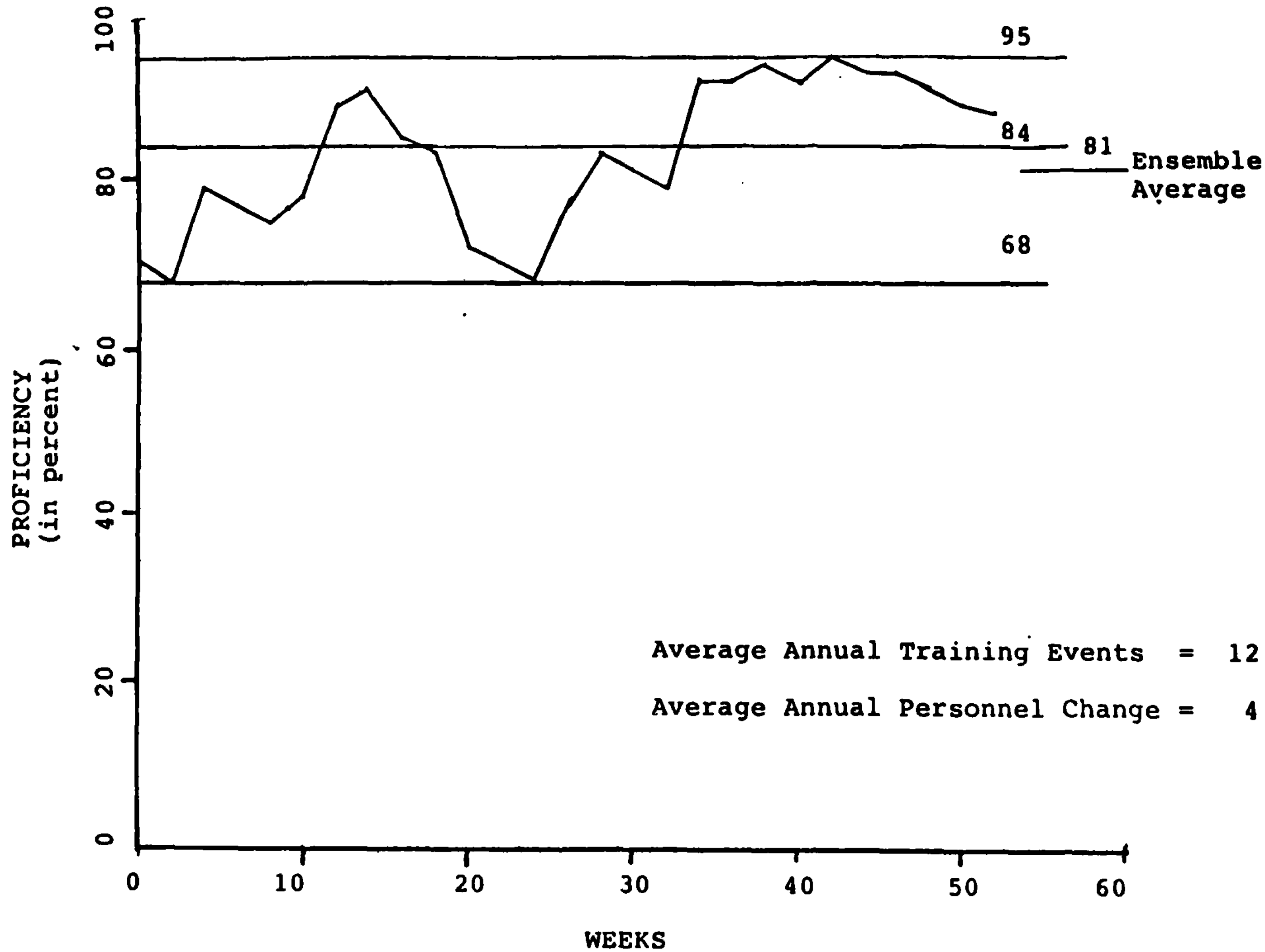


Figure B-1a. Sample Proficiency Profile for a Crew

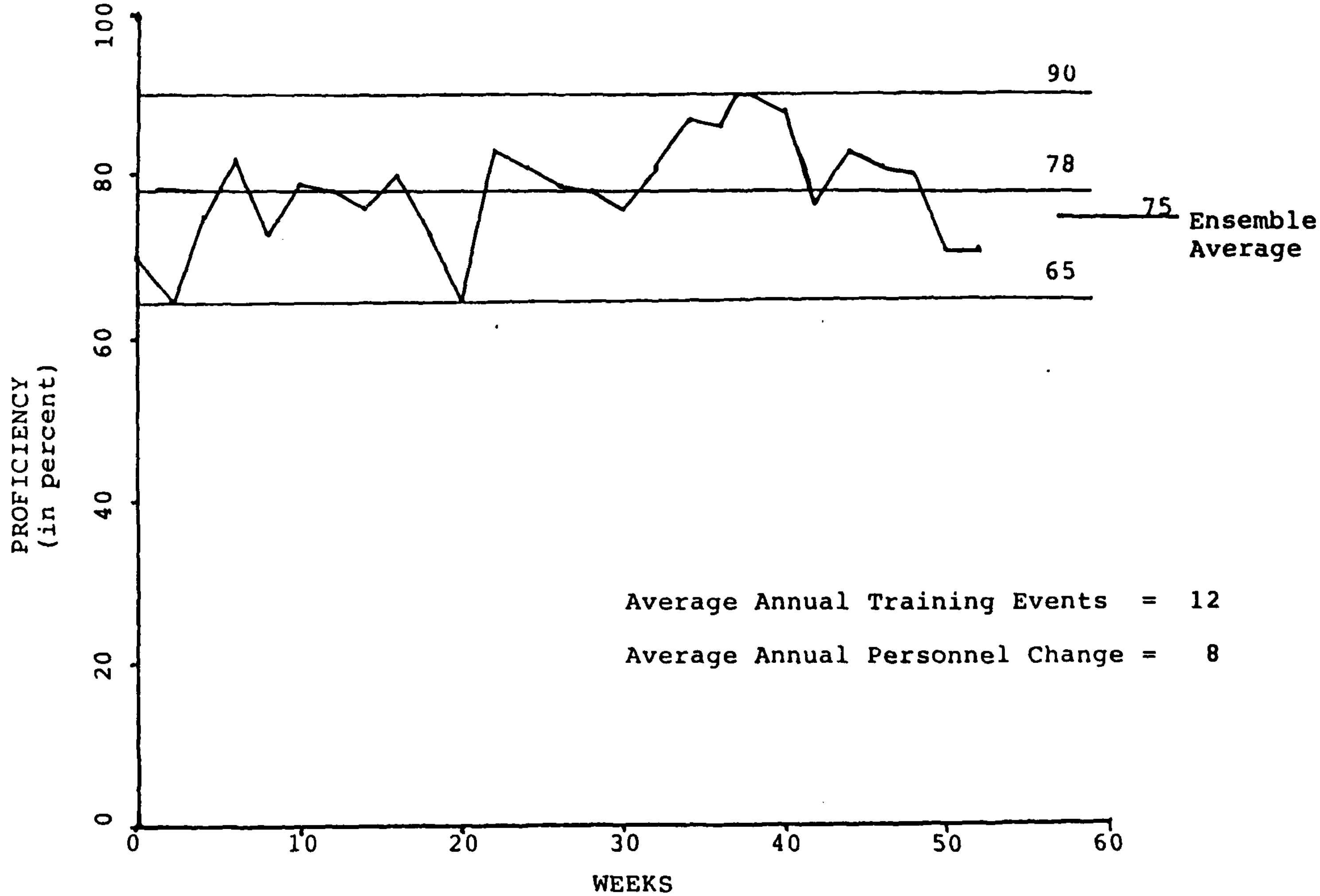


Figure B-1b. Sample Proficiency Profile for a Crew

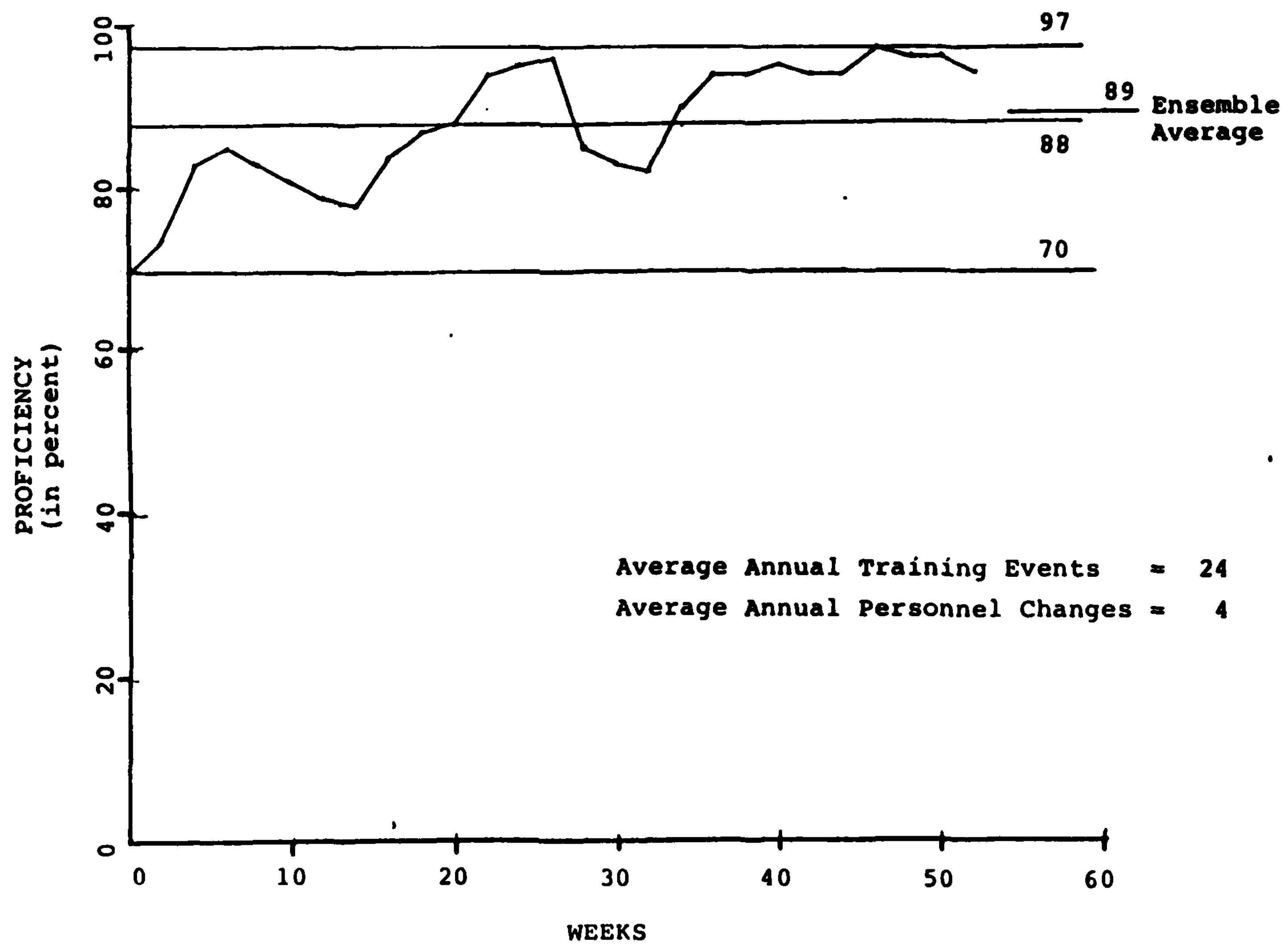


Figure B-1c. Sample Proficiency Profile for a Crew

(2) Measure the "steady-state" proficiency of an established crew (α at normal turnover rate, β at the normal live-fire training rate);

(3) Measure the gain in proficiency of an established crew being prepared to deploy (α=0 rate, β at live-fire rate of one shoot per week);

(4) Measure the decrease in proficiency of an establsined crew deployed on a ship and unable to shoot (α=0, β=0).

Ideally, the values of p, f, and t should come from measured data in MCCRES tests. This could be done most economically by simply keeping records:

(1) Of training events using standardized expenditures,

(2) Turnover, and

(3) MCCRES scores for every unit so evaluated.

It would then be possible to estimate ratios of parameters p/f and t/f. One further type of measurement would allow the evaluation of f, MCCRES tests given before and after the deployment of a unit unable to train while deployed.

By varying the standardized expenditures (including sub-caliber rounds), it would be possible to measure the dependence of p on the number of live-fire and/or subcaliber rounds fixed during a training event. It would then be possible to construct a training strategy which would "optimize" crew proficiency with respect to cost. Unfortunately, no such measured data is available, and the technique in this study is to gather subjective estimates from experienced Marine Corps personnel in order to input the parameter values we need.

The questionnaires used in the study can be found in Tab B-1 to this Annex. Our technique was to take a general subjective survey, asking for the same kind of quantitative evaluations in different ways, so that we could arrive at some concensus. In the process, we also gathered quite a bit of qualitative information. As expected, we encountered a great range of subjective estimates on the same quantitative issue.

In order to "smooth-out" the subjective evaluations, we applied equation (17) to each individual respondent's questionnaire. That is, we used the model to arrive at our best estimate of the values of p, f, and t under which each respondents mind seemed to be operating. See Tab B-2 to this Annex for specifics. We then accumulated each respondent's operant p, f, and t (and p/f, t/f, and p/t) and took means, variances, and medians. We then made our best subjective "analytic" judgment and rounded p, f, and t into representative values for each crew. We similarly distinguished another p for non-live-fire training. Table B-1 tabulates the results.

As already mentioned above, Tab B-2 contains our best estimate of each individuals operant assessment of p. We can associate this value of p with that same individual's experience concerning the number of live-fire rounds expended per live-fire training event (defined from our analysis as 1.67 live-fire days - an average of 2 two-day shoots and 1 one-day shoot.) Figures B-2a, b, and c display these relationships for each element. As can be seen, there is no obvious relationship between the amount of learning and the number of rounds fired.

This lack of a solid relationship affects the nature of our recommendations. The proposed purpose of our analysis was to recommend training ammunition dependent on relating proficiency to number of training events (using a standard number of rounds per event), and not to recommend how many rounds to fire per training event. However, it seems from our questionnaire results, that it may be a far better strategy to reduce the number of rounds per live-fire day than to reduce the number of live-fire days. The best way we can state this kind of recommendation on some quantitative basis is:

If you desire to train to a proficiency level which will imply a reduction in current allowances due to the reduction of live-fire days (based on the current doctrine governing the number of rounds per live-fire day), then you will likely lose less proficiency (not currently quantifiable) by training the same number of live-fire days with the reduced allowance. With this understanding, we now present our quantifiable results.

TABLE B-1. OPERANT MODEL PARAMETERS FOR CREW PROFICIENCY

	LIVE-FIRE LEARNING PARAMETER (p)	FORGETTING PARAMETER (f)	TURNOVER PARAMETER (t)	NON-LIVE-FIRE LEARNING PARAMETER (p')
GUN CREW	.16	.01	.02	.12
FIRE DIRECTION CENTER	.20	.01	.05	.10
FORWARD OBSERVERS (AS A GROUP)	.12	.01	.03	.10

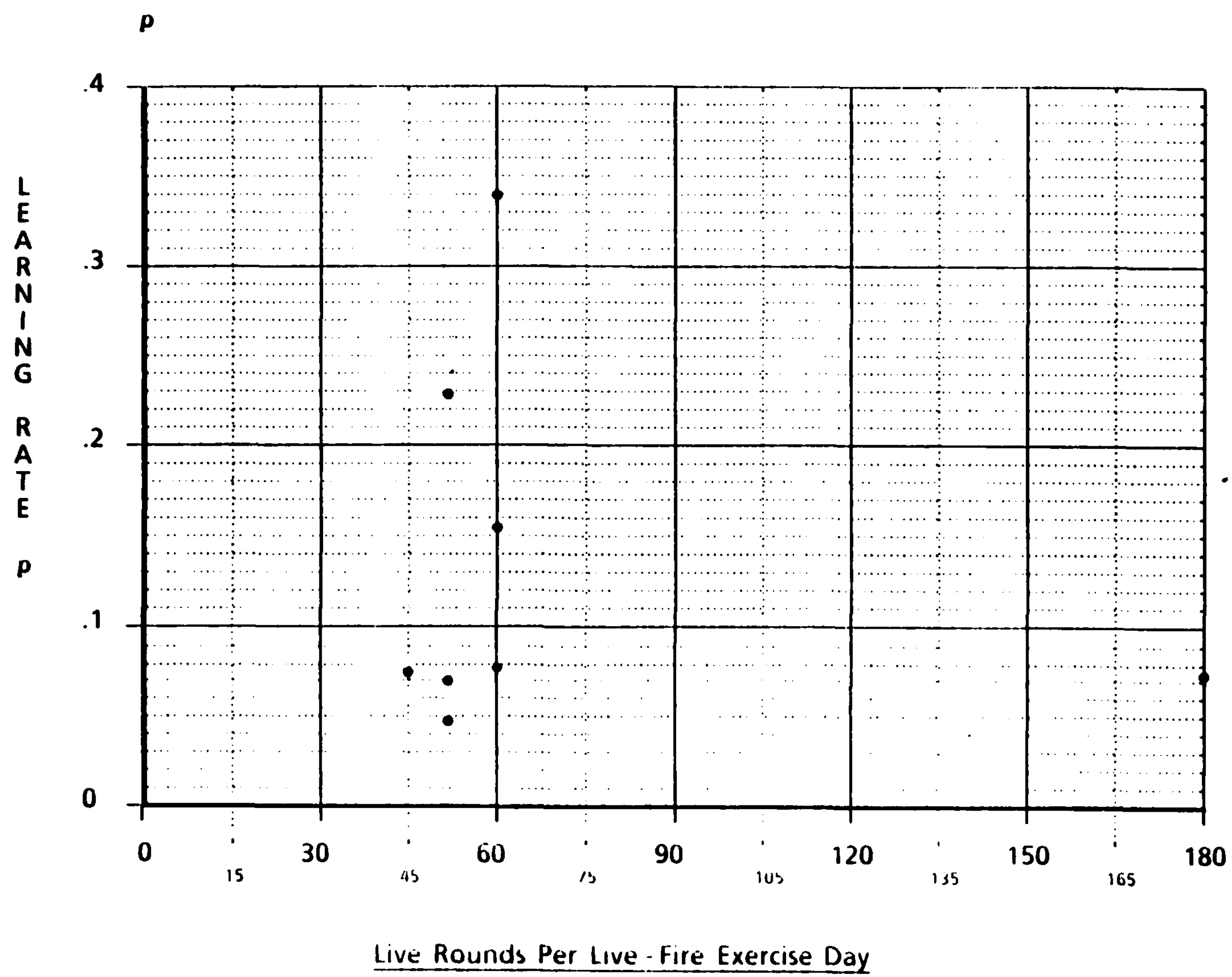


Figure B-2a. FO Learning Rate as a Function of Rounds Expended

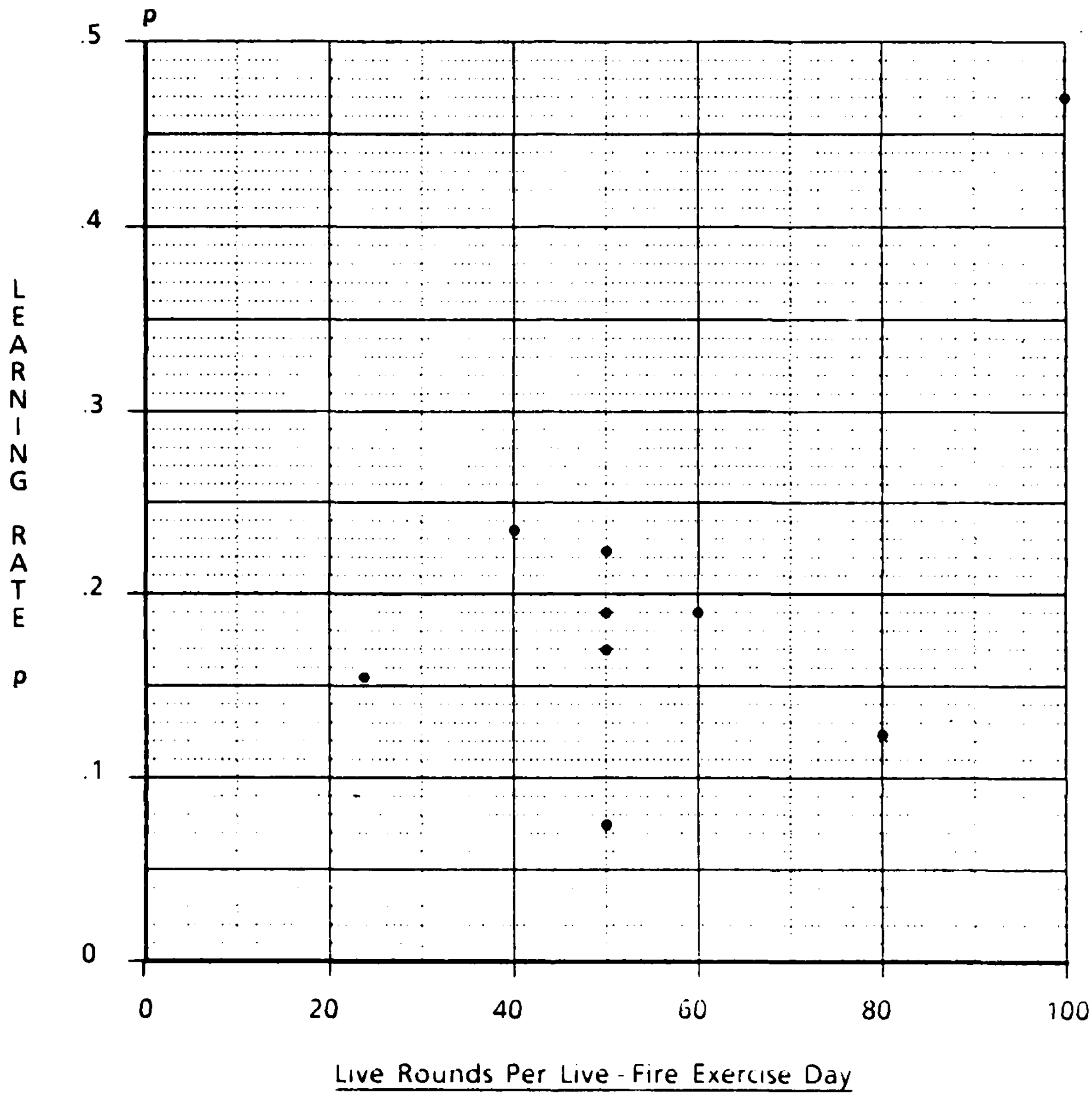
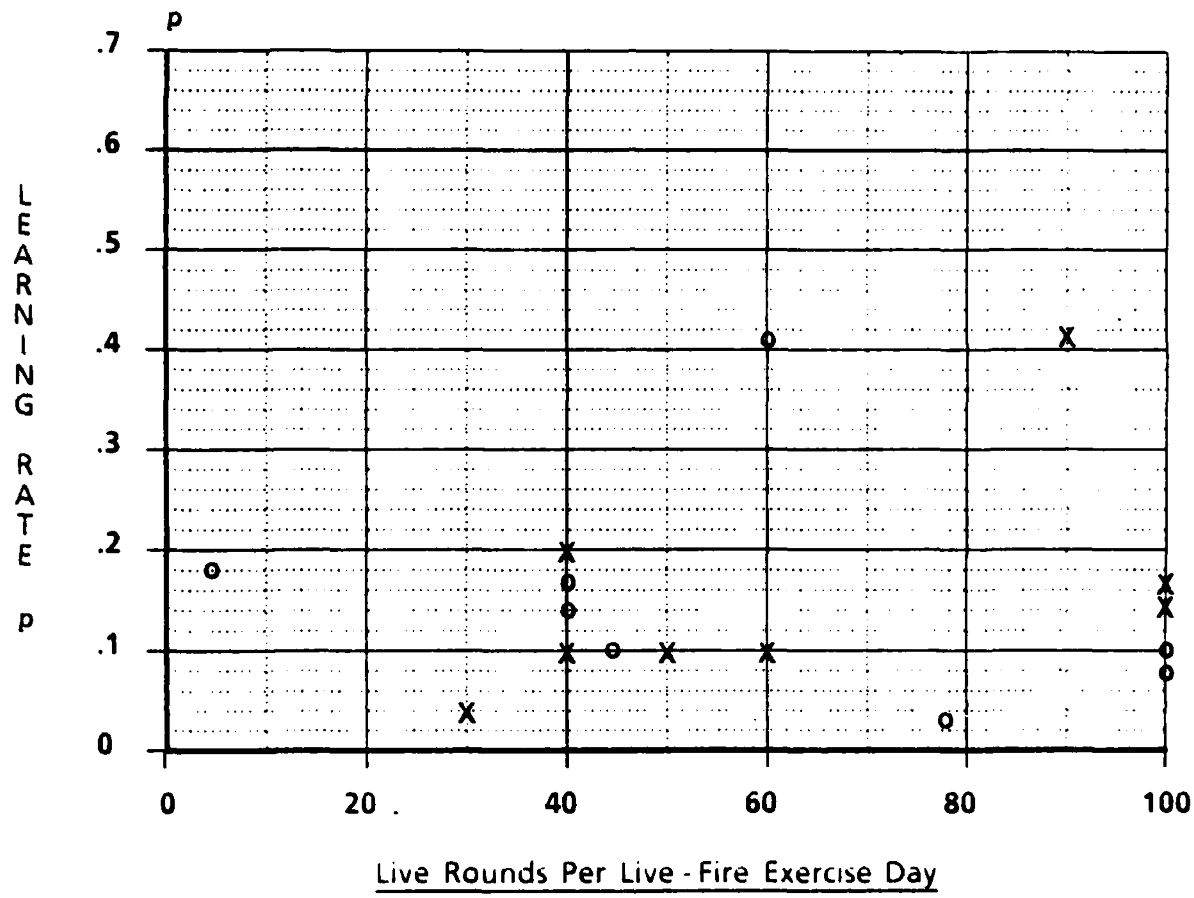


Figure B-2b. FDC Learning Rate as a Function of Rounds Expended



Notes: 1. X marks XO response.
O marks Section Chief Response
(applies to double the rounds stated)

Fiqure B-2c. Gun Crew Learning Rate as a Function of Rounds Expended

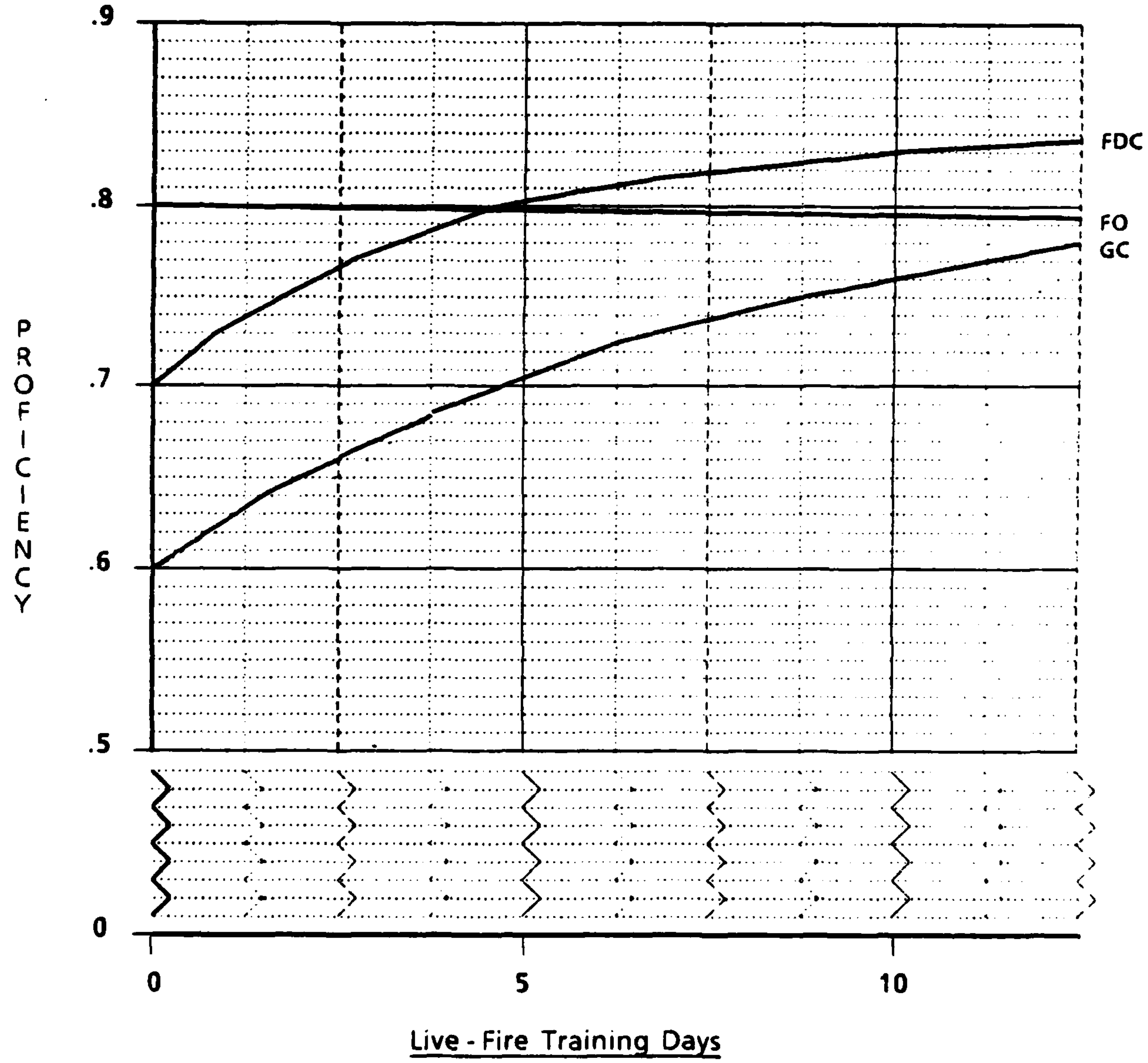
First, let's consider attainment. Figure B-3 displays the quantitative relationship between the number of days of live-fire exercises and proficiency. Each element's curve begins at the median value of proficiency, as subjectively estimated in the questionnaires, after the first live-fire training event. Each curve assumes a training rate of 3 live-fire training events, on the average, every 10 weeks (β=.3). This allows a reasonable amount of "forgetting" to impede attainment, although no turnover in personnel is assumed (α=0). Equation (17) is applied with N in multiples of 3-1/3 but interpreted in terms of training days rather than in terms of weeks of training at a rate of 26 live-fire exercise days per year. Note that at this rate the FO decreases proficiency while FDC and GC increase up to $\rho/(1-r)$ for β = .3 and the r and p appropriate for those crew from Table B-1 and α=0.

Second, Figures B-4a, b, and c display the "proficiency maintenance" curve, the quantitative relationship between the number of live-fire (including subcaliber) exercise days per year and the "steady-state" proficiency of the element's crew. This steady-state value represents the long-term average proficiency of a unit under a specified average amount of exercise days and under a specified average amount of turbulence. In equation (17) it is equivalent to setting $N=\infty$ resulting in the value $\beta p/(1-r)$.

Actually, we simplify this expression even further by removing the second order terms from the denominator. The result is

$$
\begin{aligned}
E[P(\infty)] &\approx \beta\rho/(\beta\rho+\alpha t+(1-\alpha)f), \\
&= \frac{\beta}{\beta + \alpha \frac{t}{p} + (1-\alpha)\frac{t}{p}}, \qquad (18) \\
&= \frac{\beta}{\beta + \left(\alpha \frac{t}{f} + (1-\alpha)\right)\frac{f}{p}}
\end{aligned}
$$

That is, the long-term average unit proficiency depends only on the ratios t/f and p/f and not on the specific values of p, f, and t.



Notes: 1. Assumes 5 live-fire days per 10 weeks on the average

2. Assumes no personnel turnover

Figure B-3. Proficiency Attained by New Crew

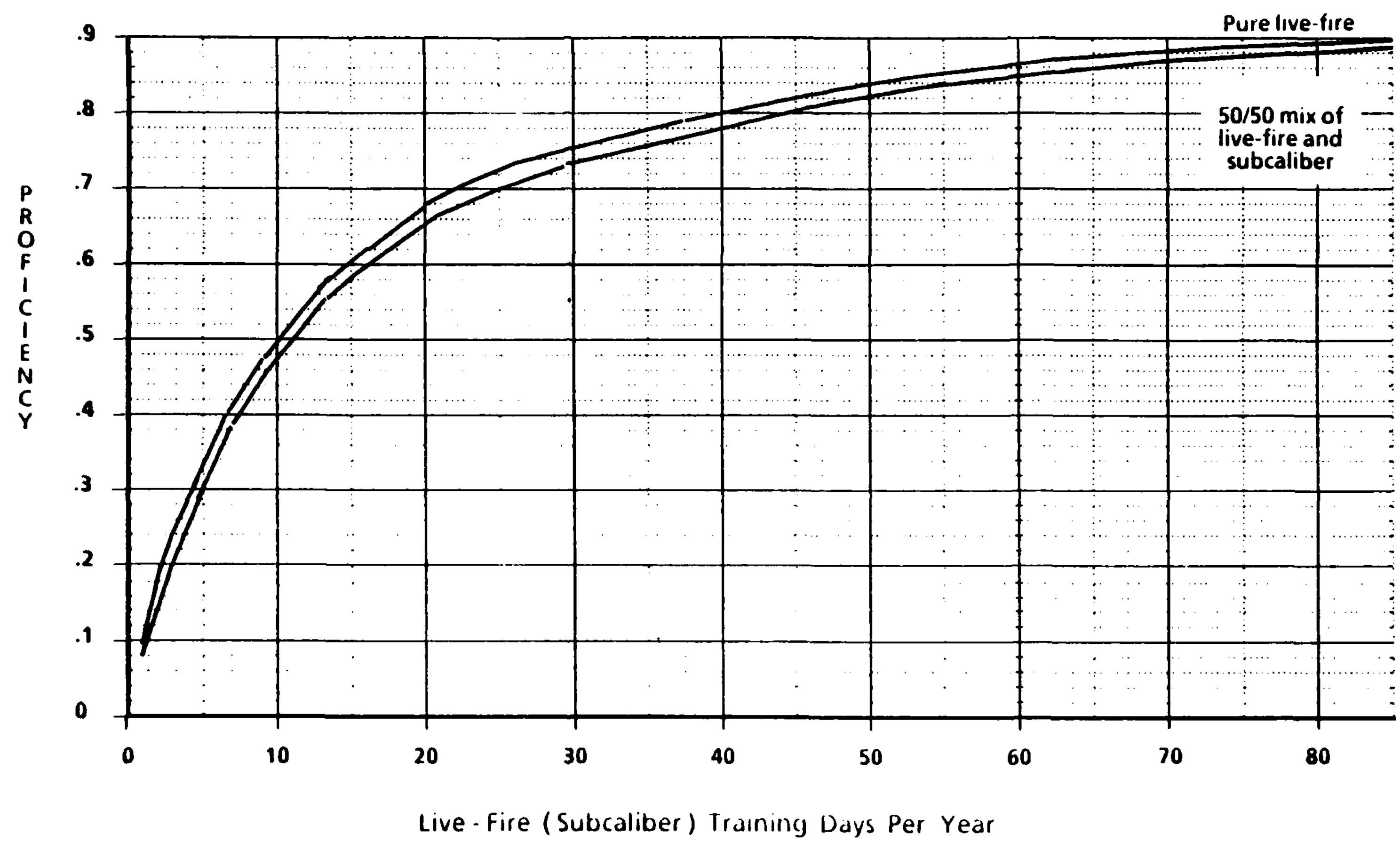


Figure B-4a. Forward Observer Maintenance Proficiency

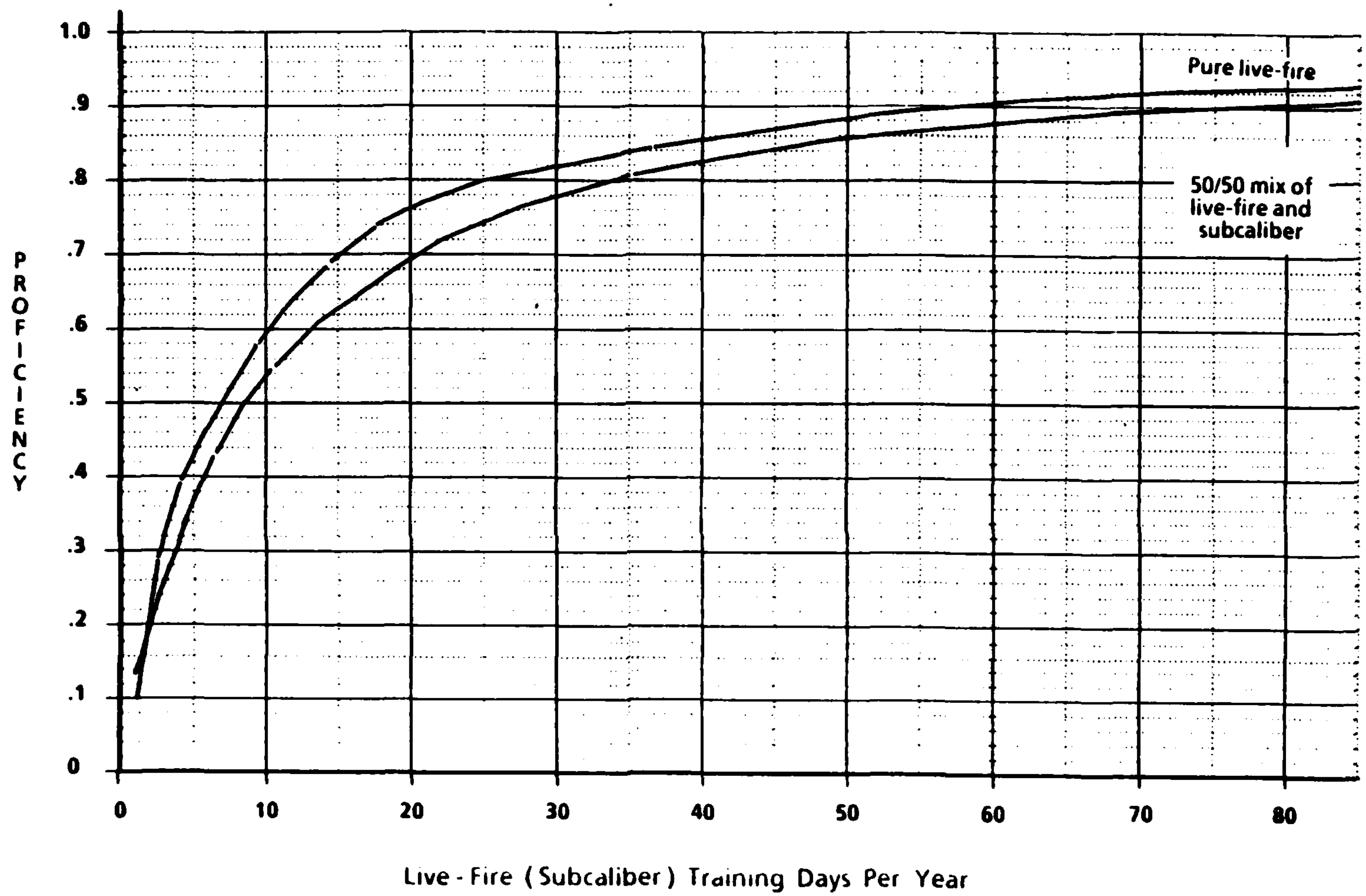


Figure B-4b. Fire Direction Center Maintenance Proficiency

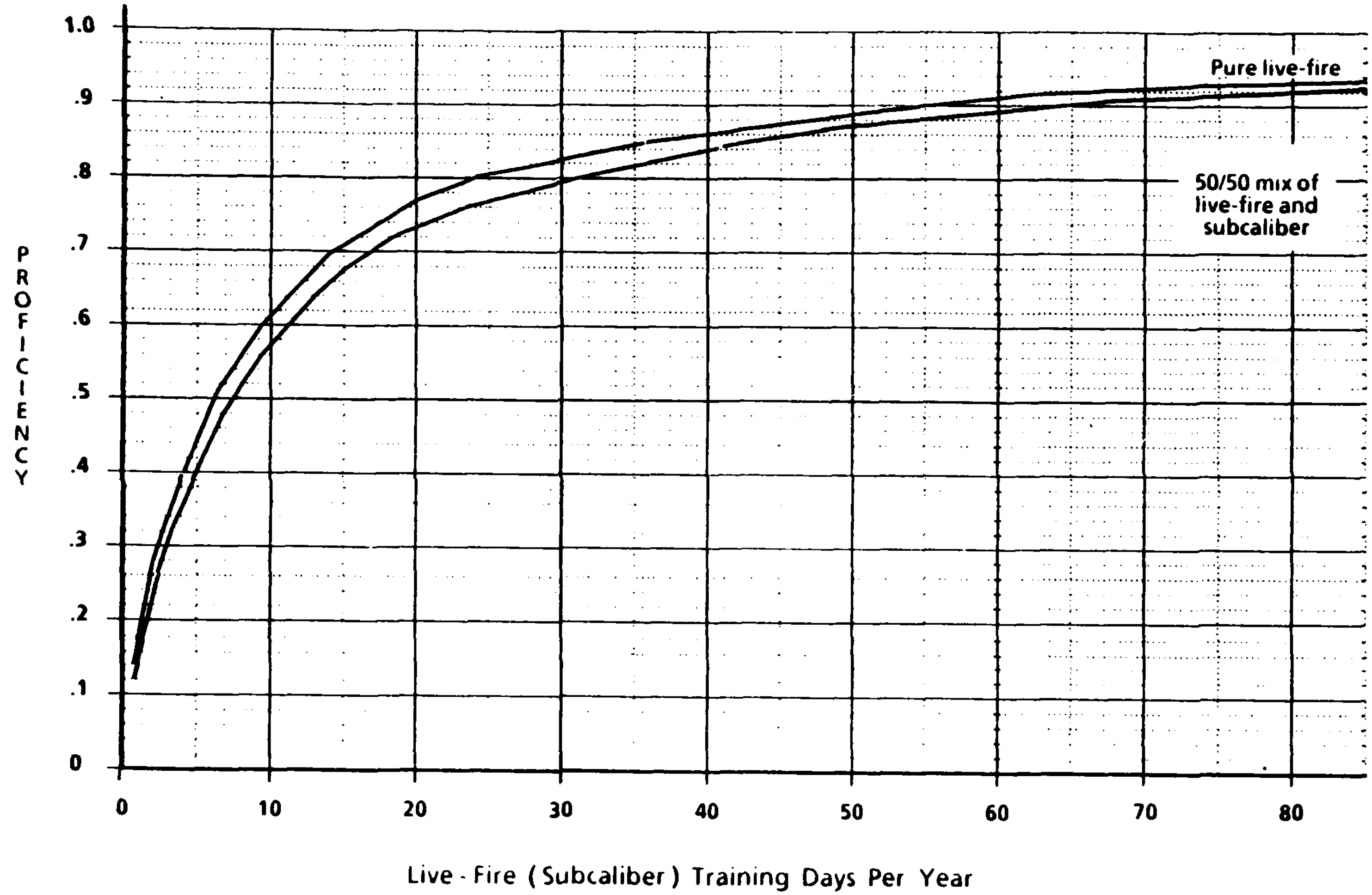


Figure B-4c. Howitzer Crew Maintenance Proficiency

Equation (18) is of the form n/n+C where n is the number of exercise days per year. In fact $\beta = n/(52 \times 1.67)$ is the fraction of training events per week. Thus $C = 52 \times 1.67(\alpha t + (1-\alpha)f)/p$. For a fixed turnover rate α, and we use median turnover per element as indicated in the questionnaires, ($\alpha = 3/26$). So as we train during more exercise days per year the proficiency increases. Under the current model, β cannot exceed 1, which is one "live-fire" training event (1.66 days) per week.

Figures B-4a, b, and c also addresses the impact of non-live-fire training. For non-live-fire training we extract a value of p appropriate to such training. See Tab B-2 again for the questionnaire analysis. This value of p is less than that associated with pure live-fire, and it is measured subjectively with the understanding that the crew members have already been trained with live-fire.

So as not to stretch our interpretation of the effectiveness of non-live fire training too far, we consider only a "50/50" mix of live-fire versus non-live-fire training. By a "50/50" mix, we are forced by our model to regard each training event as either completely non-live-fire or completely live-fire, and that such events are mixed 50/50 on the average. In this way we can use equation (14) where T_i will be either 0, or p (live-fire), or p' (non-live-fire). We then extend equation (16) to include

$$\Pr\{T_i = 0\} = 1-\beta,$$
$$\Pr\{T_i = p\} = \beta/2,$$
$$\Pr\{T_i = p'\} = \beta/2,$$

so that $E[T_i] = (p+p')/2$. Thus, the effective value of p producing the 50/50 mix curves in Figures B-4a, b, c is $(p+p')/2$.

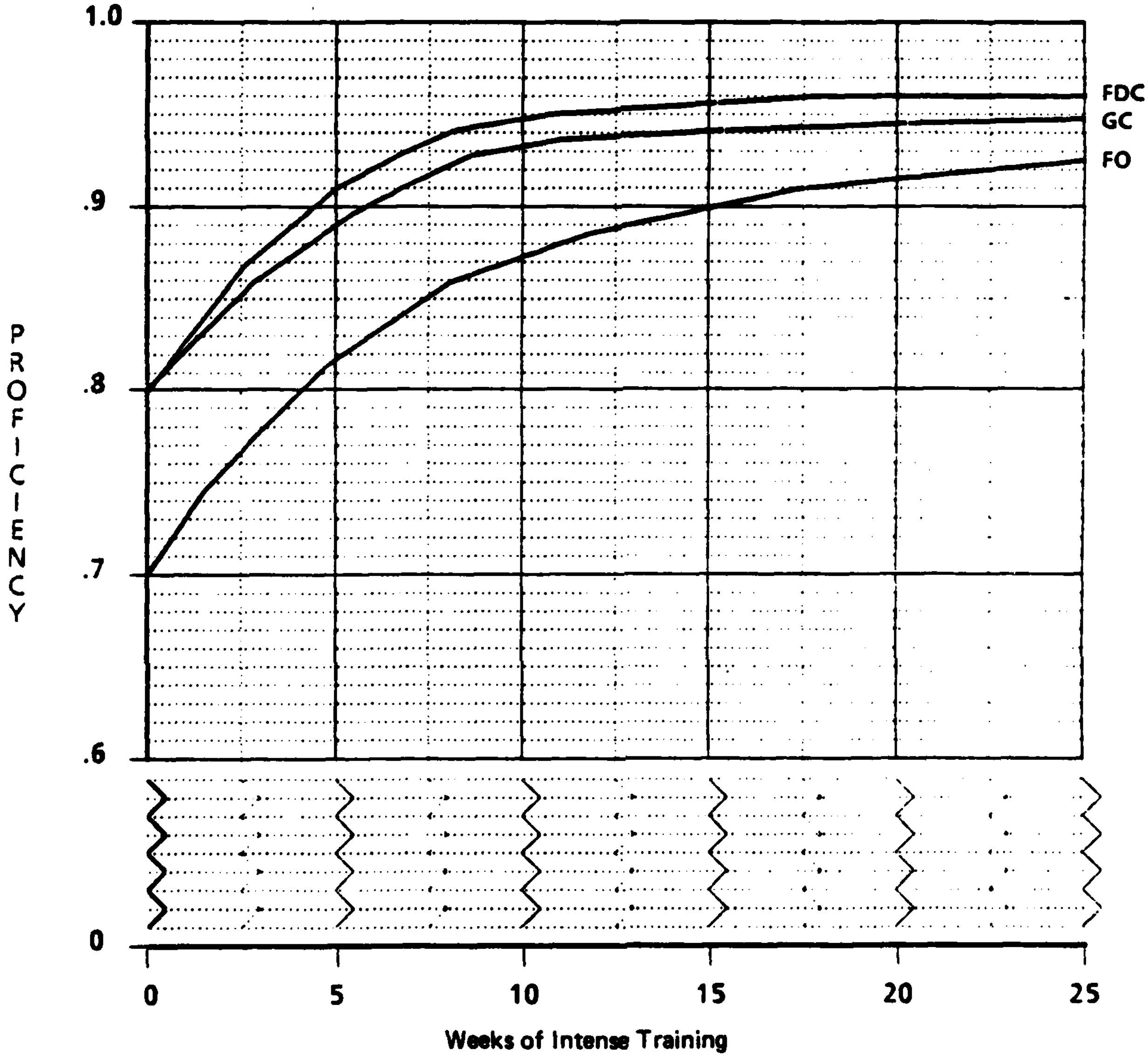
However, the questionnaires generally indicate that it is more effective to mix live-fire and non-live-fire training in the same event than to isolate their use in individual events. For example, we would recommend during a two-day shoot that the first day be devoted to non-live-fire training and the second to live-fire. This will likely provide a greater net proficiency than mixing events - but we are unable to quantify this training strategy just as we were unable to quantify the effect of reducing live-fire rounds usage in a training event. Intuitively, replacing live rounds by subcaliber rounds during a single event probably loses less training effect than by simply eliminating that number of live rounds altogether.

Rather than maintaining a high level of steady-state proficiency, it may be reasonable to maintain a lower level with the strategy of training intensely just before deployment. Figure B-5 is meant to represent this case. These graphs plot equation (17) assuming no turnover (α=0), and one training event per week (β=1). As a baseline, we assume the unit begins at P(0) = .60 and the average proficiency increases as indicated in Figure B-5 as the weeks go by.

These curves are meant to describe the relationship between differences in proficiency level and the equivalent number of weeks of training needed to bridge the gap. So, for example, in the howitzer crew curve, the difference in weeks of training between 82 percent and 92 percent is 7-1/2 weeks. This indicates that a unit maintaining 82 percent proficiency can be accelerated to 92 percent proficiency with 7-1/2 weeks of intense training.

Finally, Figure B-6 demonstrates the decline in proficiency due to lack of training. Here, α=0 and β=0 so that we assume no training and no turnover. This is characteristic of a deployed unit unable to conduct either live-fire or subcaliber training. The value for f for each element has been approximated as f=.01, and equation (17) becomes (α=0, β=0)

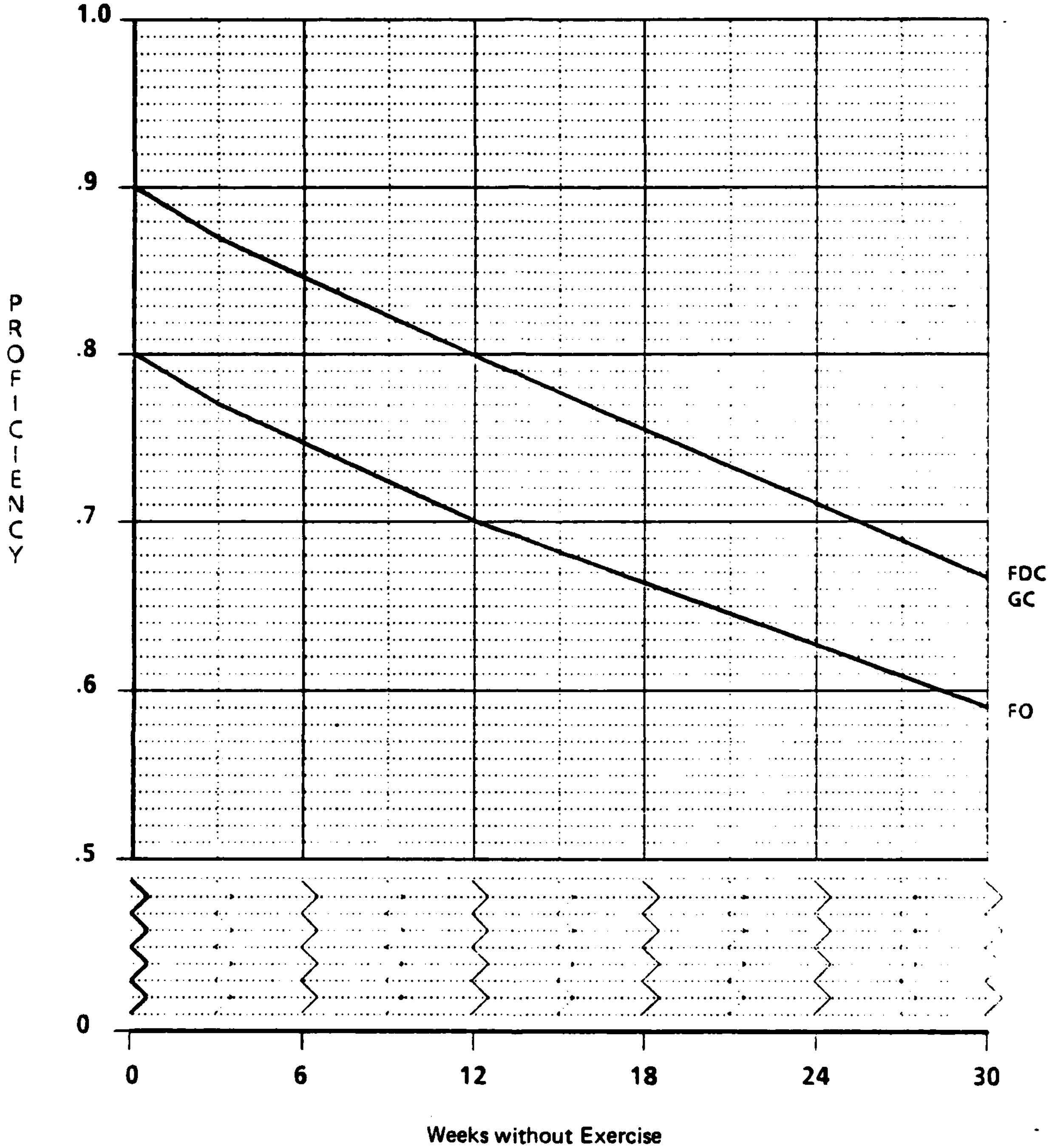
$$E[P(N)] = E[P(0)](1-f)^N \ . \tag{19}$$



Notes: 1. Assumes one live-fire exercise per week

2. Assumes no personnel turnover

Figure B-5. Predeployment Preparation Training



Notes: Assumes no turnover and no live-fire or subcaliber training.

Figure B-6. Proficiency Degradation (at Sea)

PART II
THE BATTERY PROFICIENCY MODEL

A. INTRODUCTION TO THE BATTERY PROFICIENCY MODEL

Part I of this Annex has provided us with a quantitative description of how the amount of live-fire/subcaliber training relates to the proficiency of each of the artillery battery's elements. This part of this Annex will show how to combine the proficiency of the Forward Observer (FO) with both the proficiency of the Fire Direction Center (FDC) and the proficiency of the Gun Crew (GC) in order to assess the proficiency of the battery taken as a whole.

This process of combining proficiencies is not straightforward because different indirect-fire missions depend in different ways upon each element. Thus, the combining of proficiencies is more natural in the setting of a specific mission where the impact of each element's proficiency can be more easily identified. Viewing the problem in this context is especially appropriate in view of the fact that MCCRES standards for element and Battery performance are specified within the framework of specific missions. Therefore, our measure of battery proficiency will be determined by combining certain mission-dependent proficiencies with specified weights, as we regard each mission contributes to the overall assessment of battery proficiency.

We have selected three missions as representative of battery performance: "Fire-for-Effect", "Adjust Fire", and "Coordinated Illumination". Each of these missions will be analyzed in detail to include the MCCRES Standard of performance within each mission subtask, and also to include the points of coordination between elements. The effect of coordination between elements is the single most elusive part of the Battery Proficiency Model, and it has been parameterized so that the Model can be "tuned" to data using the parameter.

This idea of "tuning" is necessary and desirable. In a MCCRES test each element, and the battery as a whole, can be evaluated, so there is a natural link between the element proficiencies and the battery proficiency. We would like to be sure that the Battery Proficiency Model, when using the element proficiencies provided by a MCCRES test, would output the battery proficiency of the same test. In order to assure this, in an average sense, we provide a free parameter which, when manipulated between reasonable bounds, will allow this match to occur.

In the sections which follow, we are concerned with computing mission-dependent proficiencies for the 3 selected missions. However, we first discuss the manner by which element performance of subtasks within any given mission is quantified.

B. QUANTIFICATION OF BATTERY ELEMENTS' PERFORMANCE

MCCRES standards for performance of the FO, FDC and GC in particular subtasks of a given artillery mission are very explicit. In particular, these standards are spelled out in terms of time and accuracy requirements for each of the Battery elements. As an example, Figure B-7 displays a typical time sequence of tasks in an "Adjust Fire" mission. MCCRES standards for performance of the FO, FDC and GC in each of these tasks are given in Figure B-8.

Suppose now that we are given proficiency levels ρFO, ρFDC ,ρGC on FO, FDC and GC, respectively (each of these ρ values satisfies $0<\rho<1$). A basic question is, how do we interpret these values in light of the MCCRES standards of Figure B-8. Consider first the standards on time. We shall introduce a one-parameter family of probability density functions $f\gamma(t)$, which will be used to characterize in each case the actual time required for an element to perform a particular subtask. Specifically, we do the following:

> Given MCCRES time standard $T_{1,0}=1$ minute on FO performance in Task 1 of Figure B-7, and given FO proficiency ρ_{FO}, choose $\gamma = \gamma_1$ such that
>
> $$\int_0^{T_{1,0}} f_{\gamma_i}(t)dt = \rho_{FO}." \qquad (2)$$

TASK 1

FO identifies target, determines target location prepares RFF and transmits RFF to FDC.

(requires time T_1)

↓

TASK 2

FDC plots target and prepares firing data

(requires time T_2)

↓

TASK 3

FDC sends data to XO; XO sends data to guns

(requires time T_3)

↓

TASK 4

Adjusting Gun(s) fire

(requires time T_4)

↓

TASK 5

Time of Flight

(requires time T_5)

Figure B-7. Typical Time Sequence at Events in an "Adjust Fire" Mission

TIME STANDARD

- FO performs Task 1 within 60 seconds
- FDC performs Task 2 within 45 seconds
- Task 3 reflects a Battery-level coordination/communication time; estimated <u>minimum</u> value for T_3 is 19 seconds
- GC performs Task 4 within 45 seconds
- In this study, the time T_5 will represent the average time of flight of an artillery round with charge 5, fired at a target at range 15,000 meters. Thus, estimated time T_5 is 35 seconds.

ACCURACY STANDARDS

- FO will locate target position to within 200 meters
- FDC will plot target position by determining Deflection (DF) and Quadrant Elevation (QE) settings to within 13 mils; at a range of 15,000 meters, this is assumed to translate into a radial error of approximately 50 meters
- GC will implement DF and QE settings again to within 13 mils; this also will be assumed equivalent to a radial error of 50 meters at the range of 15,000 meters.

Figure B-8. MCCRES Standards for Standard Performance of Tasks in Portion of "Adjust Fire" Missions

That is, condition (2) has the interpretation that given FO proficiency ρ_{FO}, the likelihood of the FO meeting the MCCRES time standard $T_{1,0}$ is ρ_{FO}. This is graphically depicted in Figure B-9. Thus, the actual time T_1 required for FO performance in task 1 is a random variable characterized by the density $f_{\gamma 1}(t)$.

This same approach is used to couple FDC proficiency ρ_{FDC} to MCCRES time standard $T_{2,0}$ = 0.75 minutes, for performance of Task 2. That is, we determine γ_2 such that

$$\int_0^{T_{2,0}} f_{\gamma_2}(t)dt = \rho_{FDC}. \qquad (3)$$

Thus, time T_2 is a random variable with density $f_{\gamma 2}(t)$. Moreover, T_1 and T_2 are assumed to be independent (as random variables). A similar constraint is applied to characterize GC performance in Task 4 of Figure B-7.

The utility of this basic approach is typified in our example as follows: that is, $f_{\gamma 1}(t)$ and $f_{\gamma 2}(t)$ are densities concentrated on $0 \leq t < \infty$. Thus the time $T=T_1+T_2$ required for completion of both Task 1 and Task 2 is a random variable with density on $0 \leq t < \infty$ given by the convolution

$$(f_{\gamma 1} * f_{\gamma 2})(t) \qquad (4)$$

Clearly a judicious choice of the family $f\gamma(t)$ is in order; i.e., one which allows (4) to be easily computed. The selection and use of such a family of densities is described later in this section.

It is apparent that by applying this technique to all tasks within a given mission, it becomes possible to quantify Battery-level performance, as regards the time aspect, in a manner which factors in both element proficiencies and associated MCCRES standards. Specifically, we shall be able to determine a probability density p(t) which characterizes the total time required for conduct of a mission. More generally we may conceptualize a density p(t,a) which characterizes both the time and accuracy aspects of Battery-level performance in a given mission. Then, given MCCRES time and

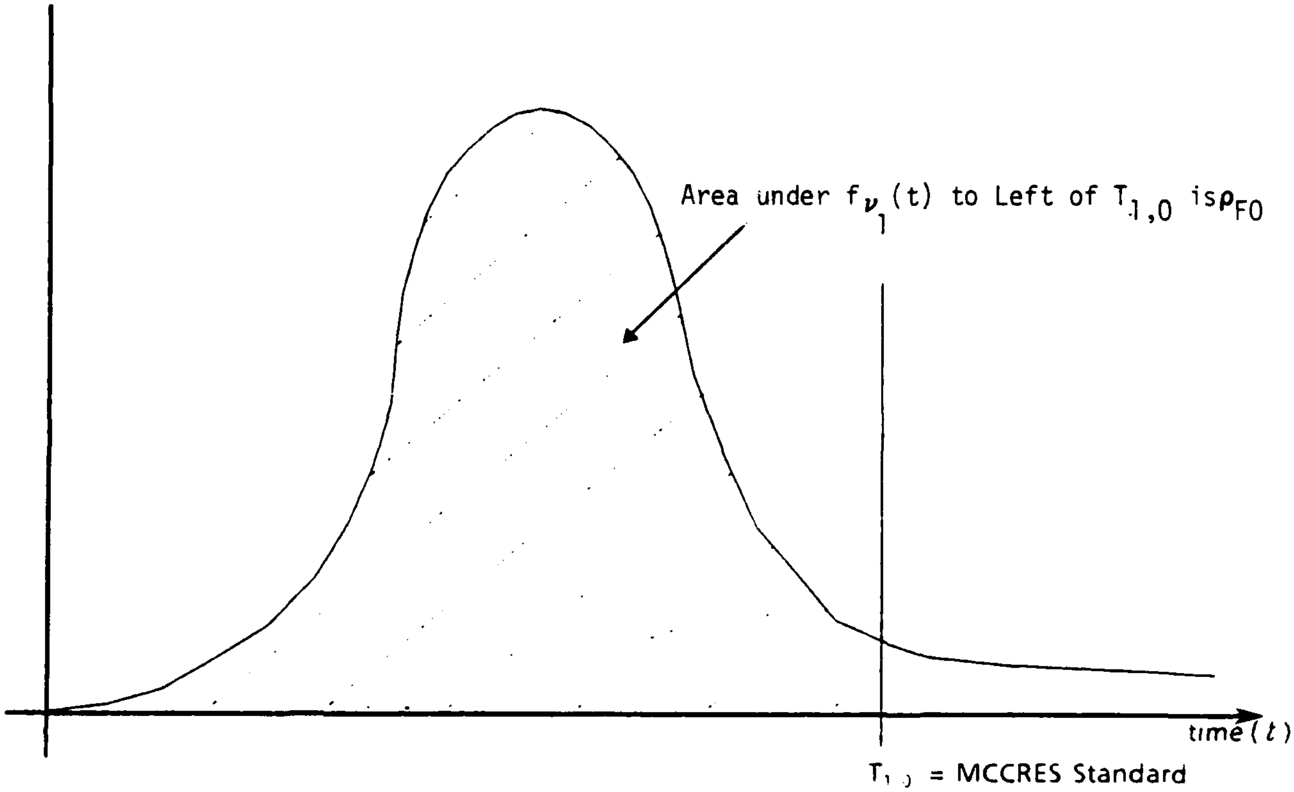


Figure B-9. Graphical Interpretation of Quantification Performance Time T_1

accuracy standards on Battery performance, we shall define Battery proficiency for a particular mission by

$$\text{Prob}\left\{\begin{array}{l}\text{MCCRES Time and Accuracy}\\ \text{Standards are met, given}\\ \text{specific mission type}\end{array}\right\} \qquad (5)$$

Notionally, we may think in terms of constructing the density p(t,a); practically, however, we shall be concerned with computation of mission-dependent probabilities represented by (5). This procedure is rather dictated by the fact that all MCCRES standards are spelled out in terms of particular type missions. Thus if we consider missions m_i , i = 1,2,...,I, define

$$\psi(\rho_{FO}, \rho_{FDC}, \rho_{GC}|m_i) \equiv \left\{\begin{array}{l}\text{Battery proficiency given}\\ \text{element proficiencies and}\\ \text{conditioned on mission}\\ \text{type } m_i.\end{array}\right\} \qquad (6)$$

Then (5) and (6) imply that

$$\psi(\rho_{FO}, \rho_{FDC}, \rho_{GC}|m_i) \qquad (7)$$

$$\text{Prob}\left\{\begin{array}{l}\text{MCCRES Time and Accuracy}\\ \text{standards are met, given}\\ \text{mission type } m_i\end{array}\right\}$$

In order to then determine an unconditioned Battery proficiency, we shall introduce mission weights α_i , i=1,2,...,I such that $\alpha>0$, $\alpha_1 + \alpha_2$ .. $+ \alpha_I = 1$, which reflect the extent to which mission type m_i contributes (on the average) to the overall assessment of Battery proficiency. The appropriate Battery proficiency $\psi(\rho_{FO}, \rho_{FDC}, \rho_{GC})$ is then given as

$$\psi\ (\rho FO, \rho FDC, \rho GC)$$

$$\sum_{i=1}^{I} \psi(\rho_{FO}, \rho_{FDC}, \rho_{GC}|m_i\ )$$

The actual construction of the mission-dependent Battery proficiencies $\psi(\rho_{FO}, \rho_{FDC}, \rho_{GC}|m_i)$ is strongly tailored to the type mission being considered. For the purposes of this study, three (3) representative missions were selected. These missions, together with the estimated weights α_i, are displayed in Table B-2.

In order to implement the procedures described above, at least from the standpoint of quantifying time aspects of Battery performance, the convolution (4) must be reasonably easy to compute. For the purposes of this study*, we shall use Gamma densities to model individual element time performances. The Gamma densities $f_{\alpha,\gamma}(t)$ are concentrated on $t \geq 0$ and for $\gamma > 1$ have the form depicted in Figure B-10. The constant represents a scale factor and will be fixed at a prescribed value. Thus, the family of densities $f_{\alpha,\gamma}(t)$ is a one-parameter family. The fundamental utility of the Gamma density $f_{\alpha,\gamma}(t)$ lies in the fact that it allows us to characterize a given performance time T_i in a mission subtask by a density which is concentrated on $t \geq 0$, "looks" more or less bell-shaped, and such that the family of densities has mathematical property: That is, if $f_{\alpha,\gamma_1}(t)$ and $f_{\alpha,\gamma_2}(t)$ are two such densities for parameter values γ_1 and γ_2, then the convolution of these densities satisfies

$$(f_{\alpha,\gamma_1} * f_{\alpha,\gamma_2})(t) = f_{\alpha,\gamma_1+\gamma_2}.$$

In particular, (9) implies that if T_1 is a random variable with density $f_{\alpha,\gamma_1}(t)$ and T_2 is a random variable independent of T_1, with density $f_{\alpha,\gamma_2}(t)$, then the random variable T_1+T_2 has density $f_{\alpha,\gamma_i+\gamma_2}(t)$.

In what follows, the densities $f_{\alpha,\gamma}(t)$ will be applied in conditions such as (2) or (3), to uniquely determine the parameter γ. This is the method by which all time variables will be quantified. (Note that, for the family of Gamma densities, the conditions (2), (3) uniquely characterize γ).

Quantification of accuracy aspects of elements performance as well as Battery performance, is mission dependent and details will be given in the following section. However, consider the following as an example of the technique to be used: The MCCRES accuracy requirement on FO performance of Task 1 in Figure B-7 is "the FO must locate the target to within 200 meters". Given this standard and the relevant FO proficiency PFO, we shall

* Note that if sample statistics on time performances were available, (4) could be computed numerically.

TABLE B-2. MISSIONS CONSIDERED IN DETERMINING BATTERY PROFICIENCY.

Mission M	Weight α_i
M_1: Fire-For-Effect	.3
M_2: Adjust Fire	.6
M_3: Coordinated Illumination	.1

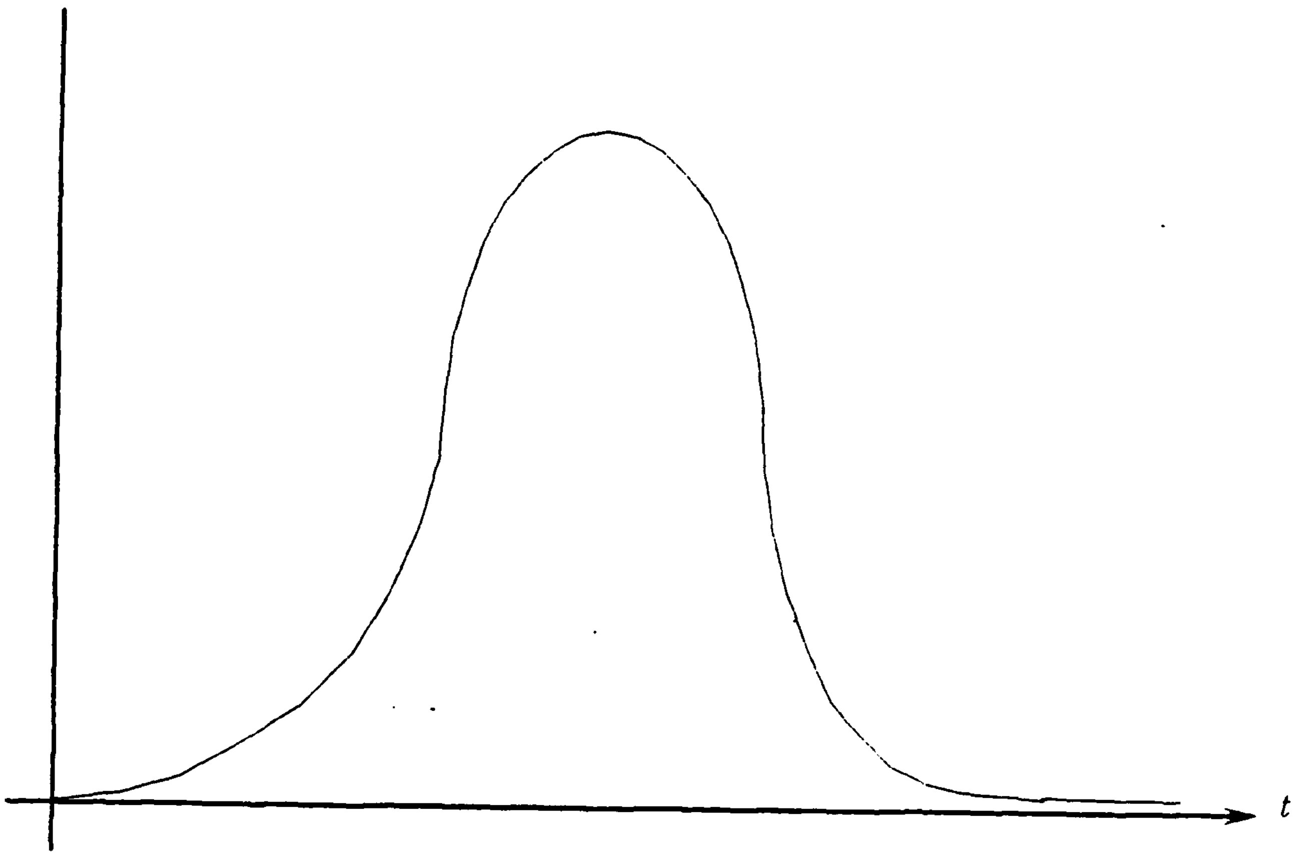


Figure B-10. A Typical Gamma Density $f_{\alpha,\nu}(t)$ for $\nu > 1$

assume that the FO's ability to sight the target is characterized by a circular normal distribution with mean the true target position, and a variance σ^2 uniquely determined by the condition

$$\text{Prob}\ \left\{\begin{matrix}\text{Target located to}\\ \text{within 200 meters}\end{matrix}\right\} = P_{FO}. \tag{10}$$

To be specific, let the target be located at (0,0) in an xy-coordinate system. Then the appropriate form for this normal density is

$$\frac{1}{2\pi\sigma^2} \exp\left\{-\frac{1}{2}\frac{x^2+y^2}{\sigma^2}\right\} \tag{11}$$

Condition (10) then becomes

$$\frac{1}{2\pi\sigma} \iint_{x^2+y^2\leq 200^2} \exp\left\{-\frac{1}{2}\frac{x^2+y^2}{\sigma^2}\right\} dxdy = P_{FO} \tag{12}$$

The integral (12) is easily evaluated (in polar coordinates) so that (12) becomes

$$1 - \exp\left\{-\frac{200^2}{2\sigma^2}\right\} = \rho_{FO} \tag{13}$$

Thus, (13) implies that

$$\sigma^2 = \sigma_{FO} = -\frac{200^2}{2\ln(1-\rho_{FO})} \tag{14}$$

More generally, then, if any of FO, FDC, GC has a MCCRES accuracy standard which can be translated into an allowable range error R_0, and a proficiency ρ is given, then performance of that element is assumed characterized by a (zero-mean) circular normal distribution with variance σ given by

$$\sigma^2 = -\frac{R_o^2}{2\ln(1-\rho)} \tag{15}$$

The manner in which this idea is implemented will be clear in what follows.

C. DETERMINATION OF THE MISSION DEPENDENT BATTERY PROFICIENCIES

1. The "Fire-For-Effect" Mission m_1

The time sequence of events in the Fire-For-Effect mission is displayed in Figure B-11. In this mission there are no adjustment rounds. The explicit MCCRES standards for this mission appear in Figure B-12.

By definition, this mission terminates when the rounds leave the tubes. Thus, time T_5 of Figure B-11 is not to be considered in evaluating total performance time for the Battery. Moreover, the time T_4 represents a coordination/communication time for the Battery. An optimistic estimate of this time is 19 seconds. This particular time element occurs in the other 2 missions considered, and will be (deterministically) fixed at 19 seconds. However, once the Battery Proficiency Model is fully assembled, this value will be uniformly incremented across missions to reflect consistency of Battery proficiency output with information obtained from the Artillery Command and Staff questionnaire.

Now, from Figure B-11 the total mission time T is given by

$$T = T_1 + T_2 + T_3 + T_4. \qquad (16)$$

As indicated in Section B.7, the procedure is to couple MCCRES time standards of Figure B-11 with relevant FO, FDC, GC proficiencies ρ_{FO}, ρ_{FDC}, ρ_{GC}, respectively, to generate Gamma densities $f_{\alpha,\gamma_1}(t)$, $f_{\alpha,\gamma_2}(t)$, $f_{1,\gamma_4}(t)$*; i.e., these densities characterize the random variables T_1, T_2, T_4, respectively. Thus, we may write $f_{\alpha,\gamma_1}(t)$, $f_{\alpha,\gamma_2}(t)$, $f_{1,\gamma_4}(t)$*

$$\begin{aligned} &\text{Prob}[T_1 + T_2 + T_3 + T_4 \leq 2.83] \\ &= \text{Prob}[T_1 + T_2 + T_4 \leq 2.83-.32] \\ &= \int_0^{2.51} f_{\alpha,\gamma_1+\gamma_2+\gamma_4}(t)dt \end{aligned} \qquad (17)$$

We now concern ourselves with the accuracy aspects of this mission. Consider first the Battery requirements. From Figure B-12 we see

*The scale factor is set equal to 0.1. This allows us to determine γ values satisfying $\gamma>1$. Moreover, Battery proficiency which is output from the final model appears to be relatively invariant with respect to varying α.

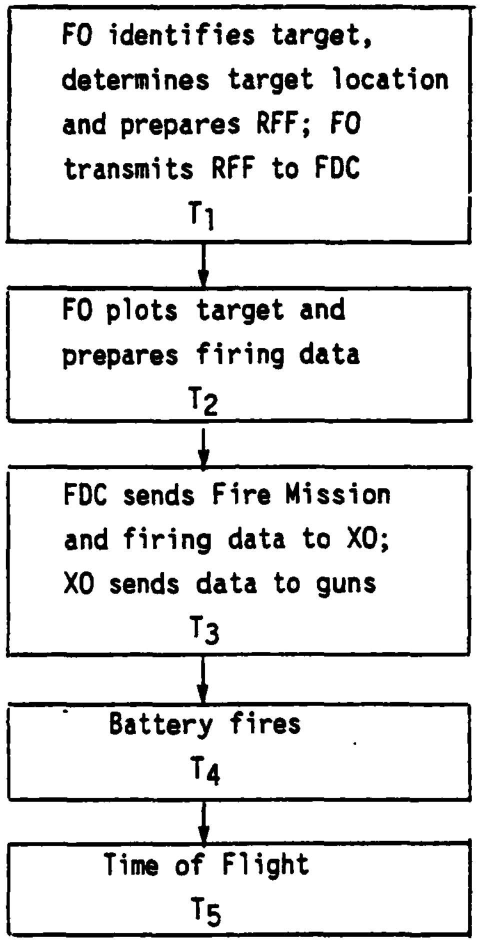


Figure B-11. Time Sequence of Events in the Fire-For-Effect Mission

Time Standards

- Standard for FO performance time T_1 is 60 seconds

- Standard for FDC performance time T_2 is 45 seconds

- No explicit standard for time T_3; estimated minimum time is 19 seconds.

- Standard for GC performance time T_4 is 45 seconds

- Time of flight T_5 for charge (?) and range 15,000 meters is 35 seconds

- Standard for Battery performance time T is 170 seconds (2.83 minutes)

Accuracy Standards

- FO will locate target position to within 200 meters

- FDC will plot target position by determining DF and QE settings to within $\pm$ 3 miles; this translates into a radial error of 50 meters

- GC will implement DF and QE settings, again to within $\pm$ 3 mils. This is equivalent to an (additional) 50 meters

- Standard for Battery performance is
  - At least 1 round of 8 fired within 50 meters of target*
  - At least 6 rounds of 8 fired within 200 meters of target

---

* In this and other missions, we assume an 8-gun battery.

Figure B-12. MCCRES Standards for Conduct of Fire-For-Effect Mission that (i) at least 1 round (of 8 fired) must fall within 50 meters of the target, and (ii) at least 6 rounds (of 8 fired) must fall within 200 meters of the target. The probability of this joint event is computed as follows. Let the ordered pair (j,i) symbolize (~):

$$(j,i) \sim \text{ i rounds within 50 meters of target and j additional rounds within 200 meters of target, with } i \geq 1 \text{ and } j \geq 5, \tag{18}$$

Define

$$\text{Prob}(j|i) \equiv \text{Probability of j additional rounds } (j \geq 5) \text{ within 200 meters of target, given i rounds } (i \geq 1) \text{ within 50 rounds of target,}$$

$$\text{Prob}(i) \equiv \text{Probability of i rounds } (i \geq 1) \text{ within 50 meters of target.} \tag{19}$$

If we consider the i rounds as independent and (separately) the j rounds as independent, we may write

$$\begin{aligned} \text{Prob}(j,i) &= \text{Prob}(j|i)\text{Prob}(i) \\ &= \binom{8-i}{j}\binom{8}{i} \bar{p}^{j}(1-\bar{p})^{8-i-j} p^{i}(i-p)^{8-i} \end{aligned} \tag{20}$$

where

$$p = \text{probability of any one of the i rounds within 50 meters of target}$$

$$\bar{p} = \text{probability of any one of the j additional rounds within 200 meters of target.} \tag{21}$$

The probabilities p, $\bar{p}$ are determined by considering FO, FDC, GC proficiencies in light of MCCRES standards on the element performance (reference: Figure B-12). That is, each of the FO, FDC, GC possible errors is characterized (independently) by variances which result from (15) applied with each of the MCCRES element accuracy standards of Figure B-12. Thus,

$$\sigma_{FO}^2 = -\frac{200^2}{2\ln(1-P_{FO})},$$

$$\sigma_{FDC}^2 = -\frac{50^2}{2\ln(1-P_{FDC})}, \tag{22}$$

$$\sigma_{GC}^2 = -\frac{50^2}{2\ln(1-P_{GC})}$$

In addition to these "proficiency-induced" error quantifications, we must account for gun round dispersion. This we characterize by a variance of $50^2 = 2500$.* Thus, the variance

$$\sigma^2 = \sigma_{FO}^2 + \sigma_{FDC}^2 + \sigma_{GC}^2 + 2500 \tag{23}$$

characterizes a (zero-mean) circular normal distribution which quantifies where a particular round may land (in the absence of any other information) Thus,

$$p = \frac{1}{2\pi\sigma^2} \iint_{x^2+y^2 \leq 50^2} \exp\left\{-\frac{1}{2}\,\frac{x^2+y^2}{\sigma^2}\right\} dxdy,$$

$$= 1 - \exp\left\{-\frac{50^2}{2\sigma^2}\right\}, \tag{24}$$

*Taken from Field Manual.

where $\sigma 2$ is as given in (23). Now, for the computation of $\bar{p}$, since (conditionally) rounds have landed within 50 meters of the target, we set $\bar{\sigma}^2 = 50^2 + 50^2$ (accounting also for dispersion) and compute:

$$\bar{p} = 1 - \exp - \left\{ \frac{50^2}{2\bar{\sigma}^2} \right\} \tag{25}$$

Identifying the admissible (j,i) pairs in the set Λ

$$\Lambda = \left\{ \begin{array}{l} (5,1),(6,1),(7,1),(4,2),(5,2),(6,2) \\ (3,3),(4,3),(5,3),(2,4),(3,4) \\ (4,4),(1,5),(2,5),(3,5),(0,6) \\ (1,6),(2,6),(0,7),(1,7),(0,8) \end{array} \right\} \tag{26}$$

allows us to compute

$$\text{Prob} \quad [\geq 1 \text{ round within 50 meters and } \geq 6 \text{ rounds within 200 meters}]$$

$$= \sum_{(j,i)\varepsilon\Lambda} \text{Prob}\ (j,i). \tag{27}$$

Thus, considering time and accuracy aspects of a mission to be independent, we have (reference: equations (7), (17) and (27)):

$$\psi\ (\rho_{FO} \cdot \rho_{FDC} \cdot \rho_{GC} \mid m_1)$$

$$= \int_0^{2.51} f_{\alpha,\ \gamma_1 + \gamma_2 + \gamma_4}(t)dt. \sum_{(j,i)\varepsilon\Lambda} \text{Prob}(j,i) \tag{28}$$

2. <u>The "Adjust Fire" Mission m_2</u>

Figure B-13, 14, and 15 depict the time sequence of events in an "Adjust Fire" mission. This mission consists of placement of an initial round (Figure B-13), several intermediate adjustment rounds (Figure B-14), and a last adjustment and FFE round (Figure B-15).

From Figure B-12, it is apparent that the total time T required for placement of the initial round is

$$T^{(I)} = \sum_{i=1}^{5} T_i^{(I)} \tag{29}$$

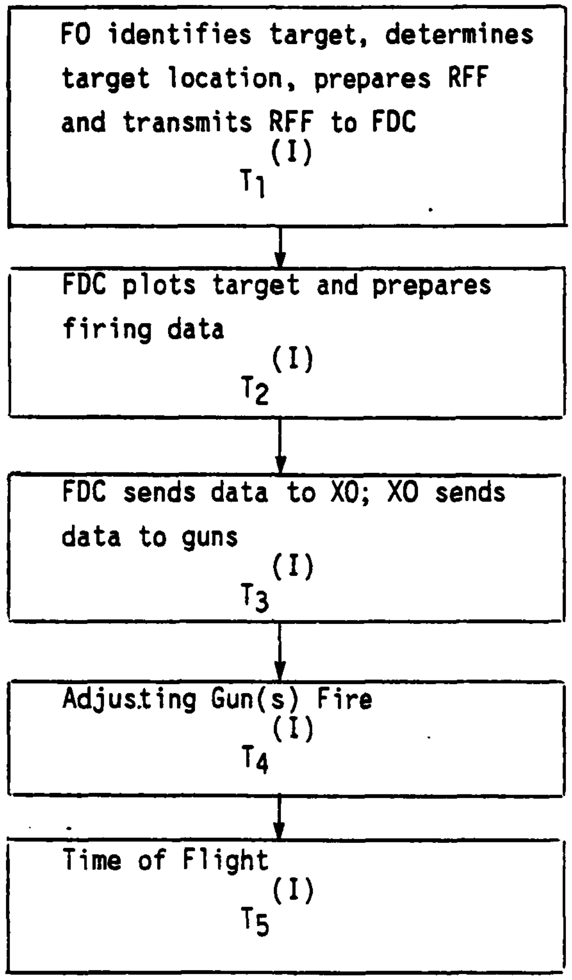


Figure B-13. Time Chart, Initial Round in Adjust Fire Mission

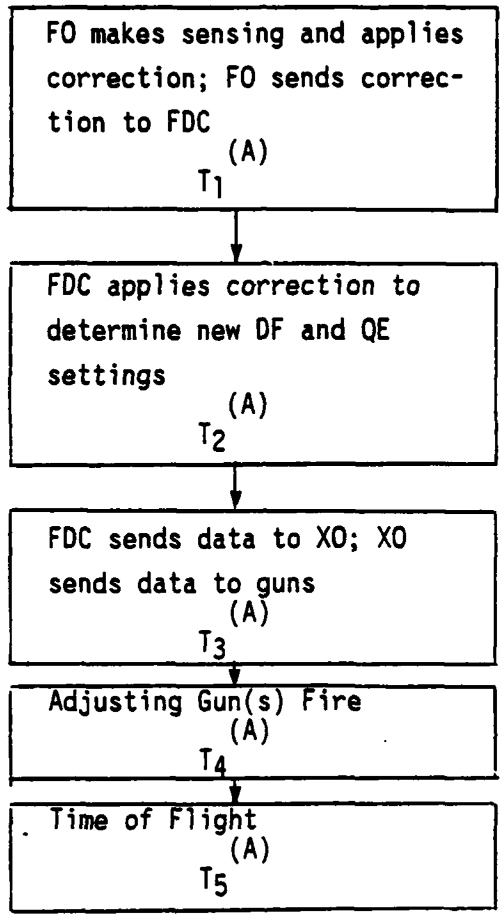


Figure B-14. Time Chart, Single Adjustment Round in Adjust Fire Mission

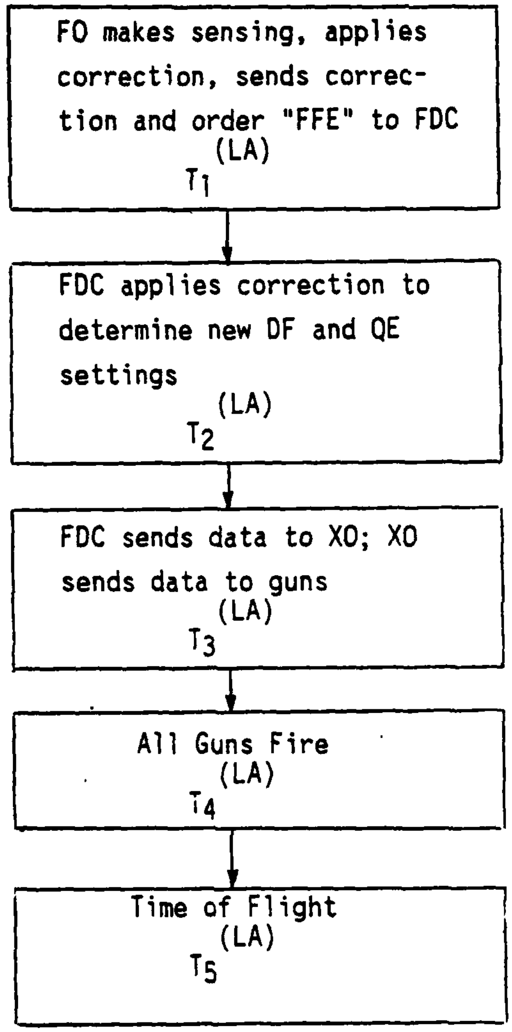


Figure B-15. Time Chart, Last Adjustment Round and FFE in Adjust Fire Mission

The time required for placement of a single intermediate adjustment round, $T^{(A)}$, is from Figure B-13

$$T^{(A)} = \sum_{i=1}^{5} T_i^{(A)} \tag{30}$$

Finally, the time required for the last adjustment and FFE is, from Figure B-15

$$T^{(LA)} = \sum_{i=1}^{4} T_i^{(LA)} \tag{31}$$

Note that (31) reflects the fact that the mission terminates when the last rounds leave their tubes (i.e. time of flight in the FFE cycle is not to be considered in evaluation of Battery performance).

Thus, if the mission requires n intermediate adjustment rounds, then the total mission time T(n) (conditioned on n) is given by

$$T(n) = T^{(I)} + n.T^{(A)} + T^{(LA)} \quad . \tag{32}$$

Our procedure now is to quantify the element time variables T_i by using the Gamma densities of Part II, B. *This will yield a statistical characterization of the random variable T(n) in terms of a conditional density p(t|n). It is also necessary, however, to use element proficiencies and MCCRES accuracy standards to determine a discrete density p(n), n=1,2,...,N, which characterizes the likelihood of each of N intermediate adjustment rounds. In this regard, it is assumed in this mission that the Battery will ultimately obtain a required 50 meter bracket on the target, and thus performance is simply a question of how many adjustments are required.

Once the density p(n), n=1,2,...,N, is determined, an unconditioned density on Battery mission time T is furnished by the marginal density.

$$p(t) = \sum_{n=1}^{N} p(t|n)p(n) \ .$$

Battery proficiency will be determined by simply applying the MCCRES battery time standard T_0 to the density p(t) to compute Prob[$T \leq T_0$].

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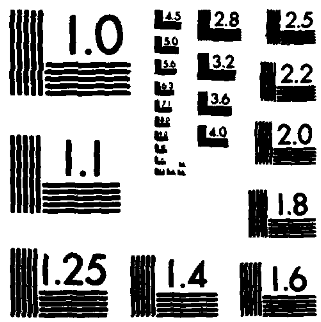


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(Keep in mind that accuracy proficiencies of FO, FDC, GC are driving factors in the construction of the density p(n), n=1,2,...,N. The details of this construction will be given shortly.)

The MCCRES standards for performance of the "Adjust Fire" mission are given in Figure B-16.

We now proceed to statistically characterize T(n) in (32). Analogous to the "Fire-For-Effect" mission, we use Gamma densities to quantify the times

$$T_1^{(I)}, T_2^{(I)}, T_4^{(I)}, T_1^{(A)}, T_2^{(A)}, T_4^{(A)}, T_1^{(LA)}, T_2^{(LA)}, T_4^{(LA)}.$$

We factor out the coordination/communication times $T_3^{(I)}$, $T_3^{(A)}$, $T_3^{(LA)}$ and times of flight $T_5^{(I)}$, $T_5^{(A)}$ as deterministic quantities (recall that $T_5^{(LA)}$ is not to be considered).

To be specific, we determine Gamma density parameters ϕ for each of the element performance times T_i by matching element performance proficiencies P_{FO}, P_{FDC}, P_{GC} to the relevant MCCRES time standards displayed in Figure B-16, (reference equation (2)). Now define

$$\begin{aligned} \mu^{(I)} &= \mu_1^{(I)} + \mu_2^{(I)} + \mu_4^{(I)} \\ \mu^{(A)} &= \mu_1^{(A)} + \mu_2^{(A)} + \mu_4^{(A)} \\ \mu^{(LA)} &= \mu_1^{(LA)} + \mu_2^{(LA)} + \mu_4^{(LA)} \\ \mu^{(n)} &= \mu^{(I)} + N\mu^{(A)} + \mu^{(LA)} \\ T_0(n) &= 1.22 + 0.9n \quad \text{(units of minutes)} \end{aligned} \qquad (34)$$

Then by property (9),

$$\text{Prob}[T(n) \leq 11] = \int_0^{11-T_0(n)} f_{\alpha, \mu(n)}(t)dt \qquad (35)$$

The quantity $T_0(n)$ accounts for the (deterministic) contribution of coordination times and times of flight.

We now consider construction of the discrete density p(n), n=1,2,...,N, which characterizes the number of adjustment rounds required

Time Standards

- Standard for FO performance time $T_1(I)$ is 60 seconds; that for times $T_1(A)$ and $T_1(LA)$ is 15 seconds
- Standard for FDC performance time $T_2(I)$ is 45 seconds; that for times $T_2(A)$ and $T_2(LA)$ is 25 seconds
- No explicit standard for times $T_3(I)$, $T_3(A)$, $T_3(LA)$, estimated minimum value is 19 seconds
- Standard for GC performance time $T_4(I)$ is 45 seconds; that for times $T_4(A)$ and $T_4(LA)$ is 35 seconds.
- Time of flight $T_5(I)$ and $T_5(A)$ is 35 seconds.
- Standard for Battery performance time T is 660 seconds (11 minutes)

Accuracy Standards

- FO will locate target position to within 200 meters
- FDC will plot target position by determining DF and QE settings to within $\pm$ 3 mils; this translates into a radial error of 50 meters
- GC will implement DF and QE settings again to within $\pm$ 3 mils. This is equivalent to an (additional) allowable radial error of 50 meters
- Standard for Battery performance is
  - 6 rounds of 8 fired with 100 meters of target

  (In as much as the mission is modeled so that 50 meter bracket is ultimately obtained, this condition is trivially satisfied)

Figure B-16. MCCRES Standards for Conduct of the Adjust Fire Mission to achieve a 50 meter bracket on the target. To begin with we consider 1st round placement error. In as much as accuracy standards for FO, FDC, GC are the same as in the "Fire-For-Effect" mission, we generate a variance σ^2 using (22), (23), i.e.,

$$\sigma^2 = s^2_{FO} + \sigma^2_{FDC} + \sigma^2_{GC} + 2500 \qquad (36)$$

Formula (36) characterizes a zero-mean circular normal distribution (reference equation (11)) which provides probabilities that the initial round will land within a prescribed range of the target. In particular, let R represent the range error random variable (in units of meters). Then

$$\text{PROB}\left[R \le Ro\right] = 1 - \exp\left[-\frac{Ro^2}{2T^2}\right] \text{(reference (12) and (13).)}$$

Now define the annulus:

$$A_k = \{R \mid 100(k-1) \le R \le 100k\} \qquad k = 1,2,\ldots,K \qquad (37)$$

Then,

$$q(k) \equiv \text{Prob}[R \varepsilon A_k]$$

$$= \exp\left\{-\frac{[100(k-1]^2}{2\sigma^2}\right\} - \exp\left\{-\frac{[100k]^2}{2\sigma^2}\right\} \qquad (38)$$

$$k=1,2,\ldots,k.$$

Moreover, each of the range error annuli A_k can be identified with a specific number of adjustment rounds required to achieve a 50 meter bracket on the target, (i.e. given that the initial round falls within A_k). This information is displayed in Table B-3. The number of adjustment rounds is given as two (2) possibilities with relative weights specified. The estimates in Table B-3, in conjunction with (38), induce the desired discrete distribution p(n), n=1,2,3,4,5, on the number of adjustment rounds required. This distribution is given as

TABLE B-3. REQUIRED NUMBER OF ADJUSTMENT ROUNDS IN THE ADJUST FIRE MISSION (NOTE: K=8)

ANNULUS	Number of Adjustment Cycles	Corresponding Weights
A_k	(N_k, N_{k+1})	$(M_{n_k}, M_{n_{k+1}})$
A_1	(1, 2)	(.5, .5)
A_2	(2, 3)	(.5, .5)
A_3	(2, 3)	(.3, .7)
A_4	(2, 3)	(.3, .7)
A_5	(3, 4)	(.3, .7)
A_6	(3, 4)	(.3, .7)
A_7	(3, 4)	(.2, .8)
A_8	(3, 4)	(.2, .8)

$$
\begin{aligned}
p(1) &= (.5)q(1) \\
p(2) &= (.5)q(1) + (.5)q(2) + (.3)q(3) + (.3)q(4), \\
p(3) &= (.5)q(2) + (.7)q(3) + (.7)q(4) + (.3)q(5) \\
&\quad +(.3)q(6) + (.2)q(7) + (.2)q(8), \\
p(4) &= (.7)q(5) + (.7)q(6) + (.8)q(7) + (.8)q(7) \\
&\quad +(.8)q(8), \\
p(5) &= 1 - \sum_{i=1}^{8} q(i)
\end{aligned}
\tag{39}
$$

Thus, using (7), (33), (35) and (39) we have

$$
\begin{aligned}
\psi\ &(P_{FO}, P_{FDC}, P_{GC} | m2) \\
&= \sum_{n=1}^{5} \text{Prob}[T(n) \leq 11] p(n) \\
&= \sum_{n=1}^{5} \int_0^{11-T_o(n)} f_{\alpha,\ \mu(n)}(t)dt \ .\ p(n)
\end{aligned}
\tag{40}
$$

3. The "Coordinated Illumination" Mission m_3

The "Coordinated Illumination" mission is the most complex of the three missions being considered. It consists of an Illumination adjustment process and a subsequent High Explosive (HE) adjustment process. Figures B-17, 18, 19, 20, and 21 depict the time sequence of events in each of these cycles.

From a modeling standpoint, the "Coordinated Illumination" mission consists essentially of two "copies" of the Adjust Fire mission, with the exception that in the Illumination phase there is no last adjustment and FFE cycle. Significant items to be computed are the discrete distributions on the number of adjustment rounds required in the Illumination phase and in the HE phase.

The MCCRES standards for this mission are enumerated in Figure B-22. It is to be noted that the Illumination and HE portions of the mission are evaluated independently. In particular, the time requirements of 7 minutes for Illumination and 11 minutes for HE are to be applied separately.

FO determines area to be illuminated and sends request for illumination to FDC

$T_1^{(I)}$

FDC plots the area to be illuminated; also determines Fire Mission, including method of fire and other firing data

$T_2^{(I)}$

FDC sends data to XO; XO sends data to adjusting gun(s)

$T_3^{(I)}$

Adjusting Gun(s) Fire

$T_4^{(I)}$

Time of Flight

$T_5^{(I)}$

Figure B-17. Time Chart, Initial Round of Illumination Phase of a Coordinated Illumination Mission

FO makes sensing for range, deflection and time (vertical placement) and determines corrections; FO sends corrections to FDC

(A)

T_1

FDC applies corrections to determine new DF, QE and timing settings

(A)

T_2

FO sends data to XO; XO sends data to adjusting gun(s)

(A)

T_3

Adjusting gun(s) fire

(A)

T_4

Time of Flight

(A)

T_5

Figure B-18. Time Chart, Adjustment Round in Illumination Phase of Coordinated Illumination Mission

Parallel Illumination Procedures	HE Procedures
FO Requests 2-point Illumination in FFE	FO Identified Target, determines target Location, prepares RFF and transmits RFF to FDC $\tilde{T}_1^{(I)}$
FO transmits FFE to FDC. Control of the time of firing illumination may be maintained by FO or passed to FDC	FDC plots target and prepares firing data $\tilde{T}_2^{(I)}$
FDC does not require a plot	FDC sends data to XO; XO sends data to adj gun(s) $\tilde{T}_3^{(I)}$
FDC sends any change in method of Fire, and QE to XO; XO sends data to guns	Adjusting gun(s) Fire $\tilde{T}_4^{(I)}$
Illumination FFE guns fire	Time of Flight $\tilde{T}_5^{(I)}$
Time of Flight	

Figure B-19. Time Chart, Initial Round of HE Phase of Coordinated Illumination Mission

Parallel Illumination Procedure	HE Procedure
IF FDC is controlling mission, FDC sends QE to XO; XO sends QE to Gun(s) firing illumination in effect	FO make sensing and determines correction; FO sends correction to FDC $\tilde{T}_1^{(A)}$
Guns Firing Illumination Fire	FDC applied correcton to determine new DF and QE $\tilde{T}_2^{(A)}$
Time of Flight	FDC sends data to XO; XO sends data to guns $\tilde{T}_3^{(A)}$
	HE Adjusting Gun(s) fire $\tilde{T}_4^{(A)}$
	Time of Flight $\tilde{T}_5^{(A)}$

Figure B-20. Time Chart, Adjustment Round of HE Phase of Coordinated Illumination Mission

Parallel Illumination Procedure	HE Procedure
IF FDC is controlling mission, FDC may or may not change the method of fire to "continuous illumination: or change the number of guns firing illumination in FFE. FDC sends QE to XO, XO sends QE (and change in method of fire) to guns	FO makes sensing, determines correction and sends correction to FDC, along with order FFE $\tilde{T}_1^{(LA)}$
	FDC applies correcton to determine new DF & QE $\tilde{T}_2^{(LA)}$
Guns Firing Illumination Fire	FDC sends data to XO; XO sends data to guns $\tilde{T}_3^{(LA)}$
Time of Flight	Guns firing HE fire $\tilde{T}_4^{(LA)}$
	Time of Flight $\tilde{T}_5^{(LA)}$

Figure B-21. Time Chart, Last Round and FFE in HE Phase of Coordinated Illumination Mission

Time Standards	Accuracy Standards
• Standard for FO performance times $T_1(I)$ and $\tilde{T}_1(I)$ is 60 seconds • Standard for FO performance times $T_1(A)$, $\tilde{T}_1(A)$, $\tilde{T}_1(LA)$ is 15 seconds • Standard for FDC performance times $T_2(I)$ and $\tilde{T}_2(I)$ is 60 seconds • Standard for FDC performance times $T_2(A)$, $\tilde{T}_2(A)$, $\tilde{T}_2(LA)$ is 40 seconds • No explicit MCCRES Standard for times $\tilde{T}_3(I)$, $T_3(I)$, $T_3(A)$, $\tilde{T}_3(A)$, $\tilde{T}_3(LA)$; estimated minimum time 19 seconds • Standard for GC performance times $T_4(I)$, $\tilde{T}_4(I)$, $T_4(A)$, $\tilde{T}_4(A)$, $\tilde{T}_4(LA)$ is 45 Seconds • Times of Flight $T_5(I)$, $\tilde{T}_5(I)$, $T_5(A)$, $T_5(A)$, $\tilde{T}_5(LA)$ is 35 seconds • Battery performance time for Illumination portion of mission is 7 minutes; for HE portion of Mission 11 minutes	• FO will locate target position to within 200 meters • FDC will plot target position by determining DE & QEsettings to within $\pm$ 3 mils; this translates into a radial error of 50 meters • GC will implement DF and QE settings to within $\pm$3 mils. This equates to an additional allowable radial error of 50 meters • Standard for Battery performance - Illumination: area adequately illuminated - HE: no more than 3 adjustment rounds; at least one round within 100 meters of target

Figure B-22. MCCRES Standards for the Coordinated Illumination Mission

We consider first the Illumination portion of the mission. MCCRES time standards and element proficiencies are used to generate Gamma densities $f_{\alpha},\ \mu_i(t)$, which serve to characterize the time elements associated with the Illumination phase of the mission. This characterization is conditioned on a number n of intermediate adjustments. Denote this time variable T(n). Specifically, define

$$T^{(I)} = \sum_{i=1}^{5} T_i^{(I)} \tag{41}$$

$$T(A) = \sum_{i=1}^{5} T_i^{(A)}$$

Then

$$T(n) = T^{(I)} + nT^{(A)} \tag{42}$$

Now set

$$\mu_1^{(I)} = \mu_1^{(I)} + \mu_2^{(I)} + \mu_4^{(I)}$$

$$\mu^{(A)} = \mu_1^{(A)} + \mu_2^{(A)} + \mu_4^{(LA)}$$

$$\mu(n) = \mu(I) + n\mu(A)$$

$$T_o(n) = 0.9 + 0.9n$$

Then

$$\text{Prob}[T(n) \leq 7] = \int_0^{7-T_o(n)} f_{\alpha},\ \mu_n(t)dt \tag{43}$$

Now, adjustments continue until "adequate" illumination has been achieved. It is estimated that the number of adjustments required to satisfy this criterion is characterized appropriately by a combination of the distribution appearing in (39), and a distribution $p_{II}(n)$, n=0,1,...,4, induced by the conditional estimates appearing in Table B-4. For convenience, denote the distribution of (39) by $p_I(n)$, n=1,2,3,...,5.

To be precise, the density $p_I(n)$ is given weight .3 and the density $p_{II}(n)$ is given weight .7. Moreover, the density $p_{II}(n)$ is given as (q(k) the same as in (38)):

$$\begin{aligned}
p_{II}(0) &= (.5)q(1) \\
p_{II}(1) &= (.5)q(1) + (.5)q(2) + (.3)q(3) + (.3)q(4) \\
p_{II}(2) &= (.5)q(2) + (.7)q(3) + (.7)q(4) + (.3)q(5) \\
&\quad +(.3)q(6) + (.2)q(7), \qquad\qquad (45) \\
p_{II}(3) &= (.7)q(5) + (.7)q(6) + (.8)q(7), \\
p_{II}(4) &= 1 - \sum_{i=1}^{7} q(i).
\end{aligned}$$

Consequently, we define the density p(n), n=0,1,...,5, as

$$\begin{aligned}
p(0) &= (.7)p_{II}(0) \\
p(1) &= (.7)p_{II}(1) + (.3)p_I(1) \\
p(2) &= (.7)p_{II}(2) + (.3)p_I(2) \\
p(3) &= (.7)p_{II}(3) + (.3)p_I(3) \\
p(4) &= (.7)p_I(4) + (.3)p_I(4) \\
p(5) &= (.7)p_I(5)
\end{aligned}$$

Thus, the (unconditioned) Battery performance time T for the Illumination part of the mission satisfies (recall (33) and (44)):

$$\text{Prob }[T \le 7] = \sum_{n=0}^{5} \text{Prob}[T(n) \le 7]p(n),$$

$$= \sum_{n=0}^{5} \int_0^{7-T_0(n)} f_{\alpha,\ \mu(n)}(t)dt \ .\ p(n). \qquad (47)$$

The HE portion of the mission in regard to the number of adjustment rounds required, is assumed characterized by the form of the density (45), with the exception that the probabilities q(k) are generated using the parameter value $\sigma^2 = 100^2 + 50^2 = 12500$. That is, at the termination of the Illumination adjustment cycles, it is assumed that the guns will be on target to the extent that a 100 meter bracket on the target has been

TABLE B-4. CONDITIONAL ESTIMATES OF ADJUSTMENT ROUNDS REQUIRED FOR THE COORDINATED ILLUMINATION MISSION

Annulus (A_k)	Number of Adjustment Cycle (N_k, N_{k+1})	Weights (M_{n_k}, $M_{n_{k+1}}$)
A_1	(0, 1)	(.5, .5)
A_2	(1, 2)	(.5, .5)
A_3	(1, 2)	(.3, .7)
A_4	(1, 2)	(.3, .7)
A_5	(2, 3)	(.3, .7)
A_6	(2, 3)	(.3, .7)
A_7	(2, 3)	(.2, .8)
A_8	(2, 3)	(.2, .8)

achieved. Represent these q-values by $q(k)$, $k=1,2,\ldots,8$. Then the density resulting from (45) and the q-values $q(k)$ will be symbolized $p_{II}(n)$, $n=0,1,\ldots,4$. The probabilities $p_{II}(n)$ will be used to weigh the time-aspect probabilities resulting from use of appropriately generated Gamma densities; i.e generating ν - values ν_i (the same procedure as in the Adjust Fire mission. Thus proceeding, define

$$\tilde{T}^{(I)} = \sum_{i=1}^{5} \tilde{T}_i^{(I)},$$

$$\tilde{T}^{(A)} = \sum_{i=1}^{5} \tilde{T}_i^{(A)},$$

$$\tilde{T}^{(LA)} = \sum_{i=1}^{5} \tilde{T}_i^{(LA)}, \tag{48}$$

$$\tilde{T}(n) = \tilde{T}(I) + n\tilde{T}(A) + \tilde{T}(LA)$$

$$\tilde{\nu}(I) = \tilde{\nu}_1(I) + \tilde{\nu}_2(I) + \tilde{\nu}_4(I)$$

$$\tilde{\nu}(A) = \tilde{\nu}_1(A) + \tilde{\nu}_2(A) + \tilde{\nu}_4(A)$$

$$\tilde{\nu}(LA) = \tilde{\nu}_1(LA) + \tilde{\nu}_2(LA) + \tilde{\nu}_4(LA)$$

$$\tilde{\nu}(n) = \tilde{\nu}_1(I) + n\tilde{\nu}_2(A) + \tilde{\nu}_4(LA)$$

$$\tilde{T}_0(n) = 1.22 + 0.9n$$

Tnen

$$\mathrm{Prob}[T(n) \leq 11] = \int_0^{11-\tilde{T}_0(n)} f_{\alpha,\nu(n)}(t)dt. \tag{49}$$

An (unconditioned) estimate of Battery performance time T in this HE portion of the mission is given by

$$\text{Prob}\,[T \leq 11] = \sum_{n=0}^{4} \left(\int_{0}^{11-\tilde{T}_0(n)} f_{\alpha,\nu(n)}(t)dt. \right) \tilde{p}_{II}(n). \qquad (50)$$

The probability of no more than 3 adjustment rounds in the He portion of the mission is clearly (reference equation (45)):

$$\tilde{p}_{II}(0) + \tilde{p}_{II}(1) + \tilde{p}_{II}(2) + \tilde{p}_{II}(3)$$

$$= 1 - \tilde{p}_{II}(4) = \sum_{k=1}^{7} q(k). \qquad (51)$$

Comment: The likelihood of at least one round of HE within 100 meters of target (for $\sigma^2 = 12500$) is essentially 1.

Thus, we have using (7), (47), (50), (51):

$$\psi(\rho_{FO}, \rho_{FDC}, \rho_{GC} | m_3)$$

$$= \text{Prob}[T \leq 7].\text{Prob}[T \leq 11] \,.\, \sum_{k=1}^{7} q(k) \qquad (52)$$

D. FITTING THE BATTERY PROFICIENCY MODEL

From the sections above, we see that we need to fit the inter-element coordination time reference, for example Task 3 of Figure B-7, so that we get rough agreement between the element proficiencies and the implied battery proficiency under MCCRES evaluation. We do this by incrementing the minimum coordination/communication time of 19 seconds uniformly across missions so that the Battery Proficiency Model produces outputs consistent with subjective data gathered from the Artillery Command and Staff Questionnaire. We display the relevant subjective data from the Artillery Command and Staff Questionnaire in Table B-5.

We see in Table B-5 twenty-four items grouped into 3 sets of 8. The first set represents the subjective evaluation of the 8 respondent's

TABLE B-5. BATTERY PROFICIENCY VERSUS ELEMENT PROFICIENCIES (IN PERCENT)

	BATTERY	FO	FDC	HC
1	70	90	50	70
2	70	90	70	70
3	60	50	70	70
4	60	80	80	90
5	90	80	90	90
6	40	50	50	40
7	50	80	30	50
8	70	80	70	60
1	90	100	80	90
2	90	90	90	90
3	80	70	90	90
4	80	90	90	100
5	90	90	90	90
6	60	70	60	60
7	80	90	80	80
8	80	90	80	80
1	100	100	100	100
2	90	90	90	100
3	90	80	90	100
4	100	100	100	100
5	90	90	100	90
6	70	70	70	70
7	90	90	90	90
8	90	90	90	80

concerning the MCCRES scores (in 10's of percent) which would accrue to a battery which had been through one "shoot" together before the MCCRES scoring. The second set of 8 represents the analogous scores after four "shoots" together. The third set is after 7 "shoots" together. All the respondent's, except #4, place the battery proficiency somewhere between the element proficiencies. Number 4 seems to find some substantial effect on battery proficiency due to the amount of training together.

We would like to construct some simple model which would "smooth" these data. The model we choose is of the form

$$P_{bat} = (P_{FO})^a (P_{FDC})^b (P_{GC})^c \cdot (e)^d \qquad (53)$$

which says that battery proficiency is some modification of the product of the independent proficiencies of the elements. This modification is in the form of a product of roots of the element proficiencies times a constant e^d where e is the base of the natural logarithms and a, b, c, d are parameters to be determined from data.

By transforming equation (53) by logarithms we get a linear model in the logarithm of proficiency:

$$\ln(P_{bat}) = a \ln(P_{FO}) + b \ln(P_{FDC}) + c \ln(P_{GC}) + d. \qquad (54)$$

Now we can use a linear regression to fit equation (54) to any set of data for (P_{bat}, P_{FO}, P_{FDC}, P_{GC}) that we choose. Tab C of this Annex discusses the method we use to determine the parameters a, b, c, and d.

If we fit all the data in Table B-5 we find

$a = .196 \quad b = .394 \quad c = .294 \quad d = -.017$.

If we exclude all battery entries below 70% proficiency we get

$a = .252 \quad b = .417 \quad c = .270 \quad d = -.023$,

which is reasonably consistent with the first set, cuts the residuals by a factor of 4, and does not force us to fit at proficiencies where we do not expect to operate. The hardest entry to fit in this case is the 4th entry in the second set of Table B-5. This entry represents the view that battery proficiency can be distinctly less than the proficiency of the least proficient element.

However, our simple model in equation (53) is not meant to account for coordination proficiency explicitiy. And although we could represent coordination proficiency in terms of a decrease in coordination time as the battery trains together, we do not have any consistent measurements which would allow us to do so. We have fit the data sets in Table B-5 separately, but we have found no consistent trend in the d parameter, or in the geometric mean of a, b, and c, which would indicate an increasing coordination (d gets smaller) as we move from the first set (one shoot) to the last set (seven shoots).

With this information in mind, we fit the parameters again excluding datum 4 of the second set in Table B-5. We get

$$a = .353,\ b = .440,\ c = .376,\ d = -.009\ .$$

With this set, the battery proficiency depends in a more balanced fashion on all the element proficiencies with the FDC slightly more influential than the others: Since d = -.009 is quite small, we might try to fit this again forcing d = 0. We then get a = .451, b = .471, c = .386.

These values of a, b, c, and d cannot be taken too seriously. For example, if we include two more datum by adding in the #4 entries from the first two sets of Table B-5 then we find the best parameters to be (but the residuals almost triple)

$$a = .468,\ b = .479,\ c = .071,\ d = -.019$$

so that now the FDC and FO are equal contributors and the GC can be ignored in the calculation of battery proficiency. Again forcing d = 0, we get a = .686, b = .546, c = .079. With all these combinations, we make the analytic judgment

$$P_{bat} \approx (P_{FO})^{.5}\ (P_{FDC})^{.5}\ (P_{GC})^{.4}. \qquad (55)$$

which places equal weight on FO and FDC and slightly less on GC. Also the coefficients are of such a size as to yield a reduced P_{bat} indicative of some coordination depression.

To fit the Battery Proficiency Model we set $P_{FO} = P_{FDC} = P_{GC} = .8$ and equation (55) tells us $P_{bat} = .73$. We then set our coordination time so that the Battery Proficiency Model predicts about $P_{bat} = .73$. A good coordination time seems to be about 29 seconds, which lies in between the minimum of 19 seconds and the maximum of 45 seconds (subjective extraction from Field Manual procedures). Thus, 29 seconds is a reasonable average coordination time for a battery that has trained together so that the element proficiencies are all about 80 percent.

Although continued training together would likely increase the coordination proficiency (represented by an average decrease in coordination time) we have no current means of representing it. Furthermore, turnover among in the FOs, FDO, XO, and Section Chiefs will affect this value in some negative way, but we have no model of learning or unlearning effects upon this "coordination crew". Therefore, in all analyses to follow, the Battery Proficiency Model will be run with a coordination time of 29 seconds.

E. RESULTS FROM THE BATTERY PROFICIENCY MODEL

Based on the fit of the previous section, we are now able to apply the Battery Proficiency Model in order to assess the effects of training on battery performance. To do this, we first assume that the Battery trains together, so that the number of training events each element participates in is the same, and is equal to the number of training events experienced by the battery overall. We address differential elements training afterwards.

The curves in Part I of this Annex describe the proficiency levels of each element depending on training. For the same amount of training (number of events or number of events per year) the Exhibit then represents the average proficiency levels of the FOs, the FDC, and the GC. Putting these three proficiencies into the Battery Proficiency Model will yield an overall battery proficiency which we can then plot as a function of amount of training.

Figure B-23 represents the battery attainment curve, the quantitative relationship between the number of training events (one to two days of live-fire exercises) and proficiency. This curve assumes a training rate

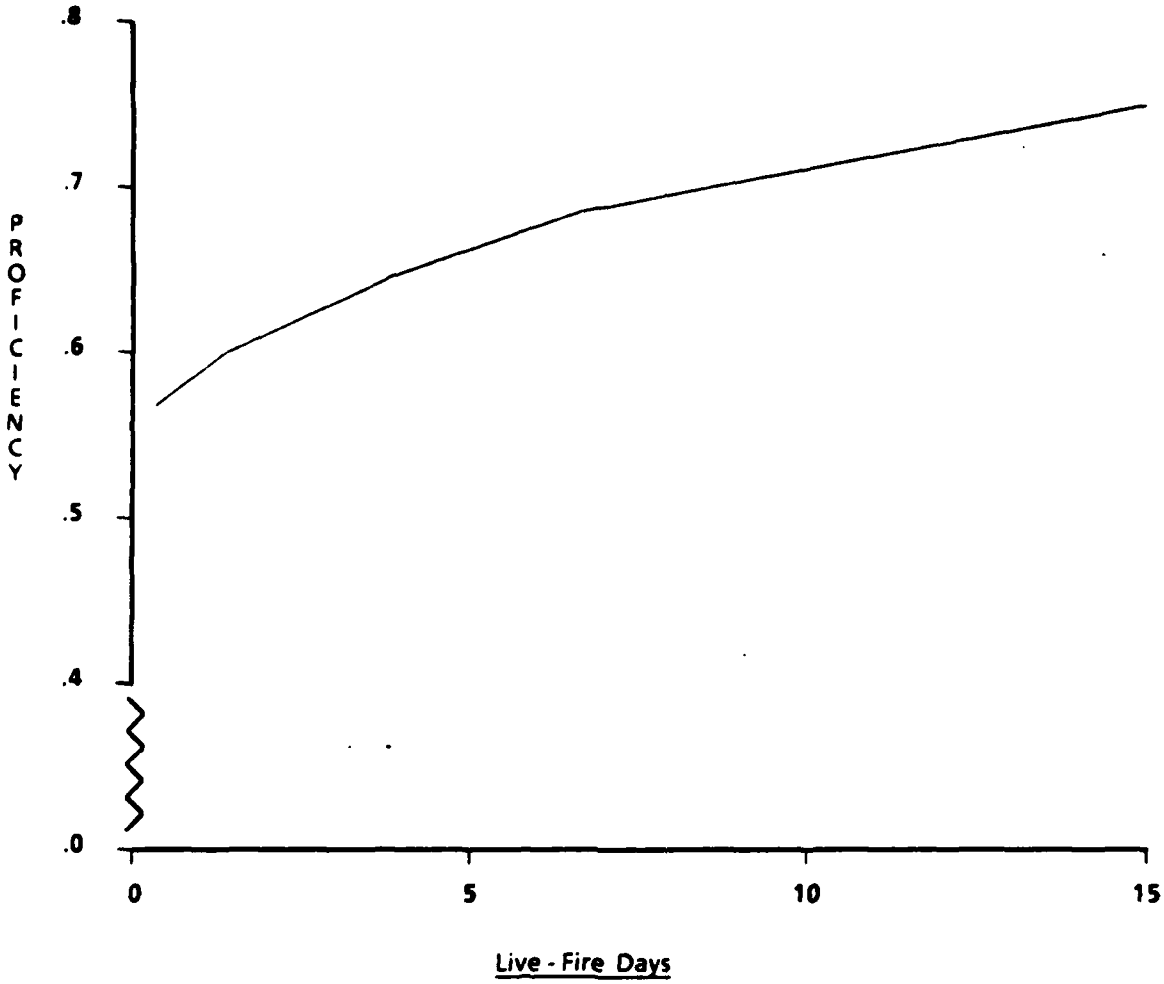


Figure B-23. Battery Attainment

of 3 live-fire training events, on the average, every 10 weeks (about 5 live-fire days).

Figure B-24 represents the "proficiency maintenance" curve. It displays the quantitative relationship between the number of live-fire exercise days, or mixed live-fire/subcaliber exercise days, per year and the "steady-state" or "long-term" proficiency of the battery. By nature of its assembly from the element curves in Part I, Section E, it includes the median turnover recognized by those elements, and all the caveats of Section E apply.

Figure B-25 represents the gain in proficiency due to intense training just before deployment. That is, this curve assumes no turnover and that one live-fire exercise will occur per week. Using this curve, it is possible to approximate how long it would take to bring a battery up to a desired proficiency when it has been maintained at a lower state of proficiency - some number of weeks of training will be needed to bridge the gap. Finally, Figure B-26 describes the decay of proficiency due to lack of training while a battery is, for example, maintained at sea.

The results described so far apply under the situation in which the battery elements all train together. However, it might be useful to give some elements some additional training in the hope of a cost effective increase in overall battery proficiency. In order to identify where this might best occur, we can use the Battery Proficiency Model in an analytic mode.

For example, suppose the battery is operating at the 75 percent level. Then first fix the FO at 75 percent and look at the combinations of FDC proficiency and GC proficiency which maintain the battery at about 75 percent. Figure B-27 describes such a relationship. Similarly fix FDC at 85 percent and let FO and GC float; Figure B-28 represents this case. Figure B-29 represents the analogous case holding the GC at 85 percent.

These figures indicate that the battery's performance is most critically dependent on FO proficiency. Thus, it is reasonable to recommend steps which would lead to cost-effective proficiency increases

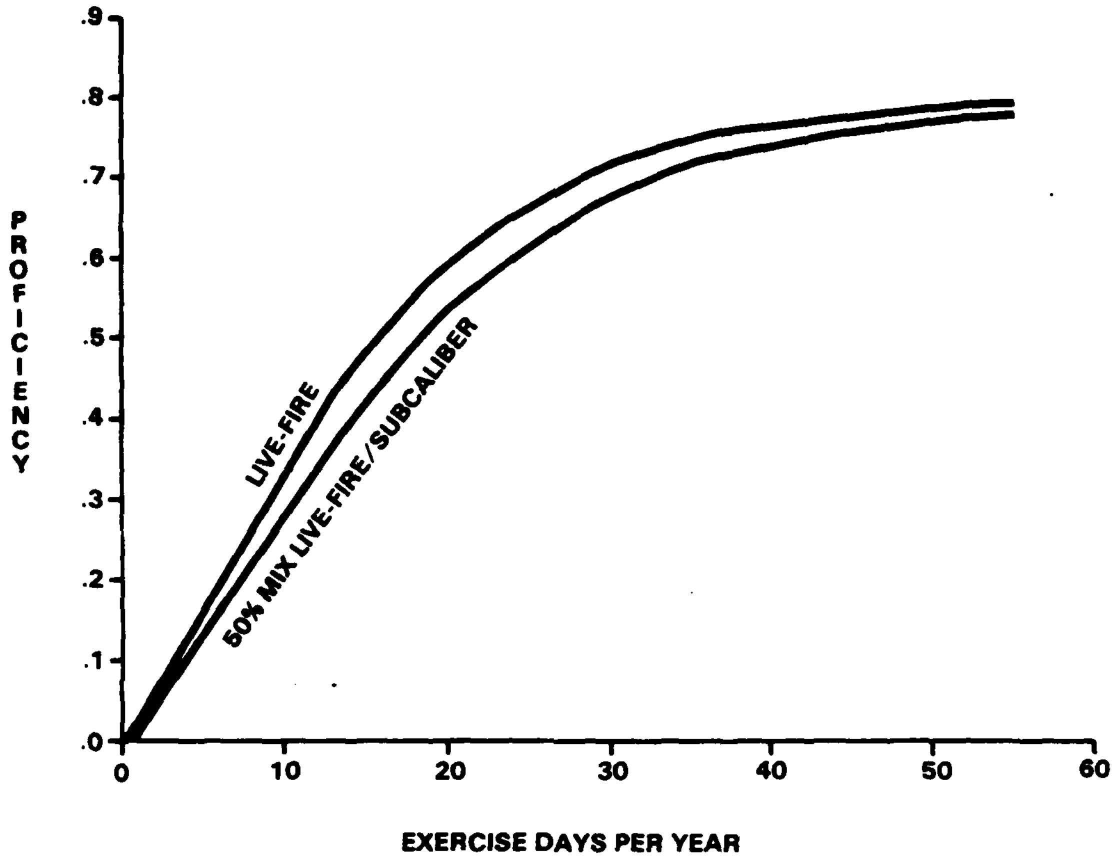


Figure B-24. Battery Proficiency Maintenance

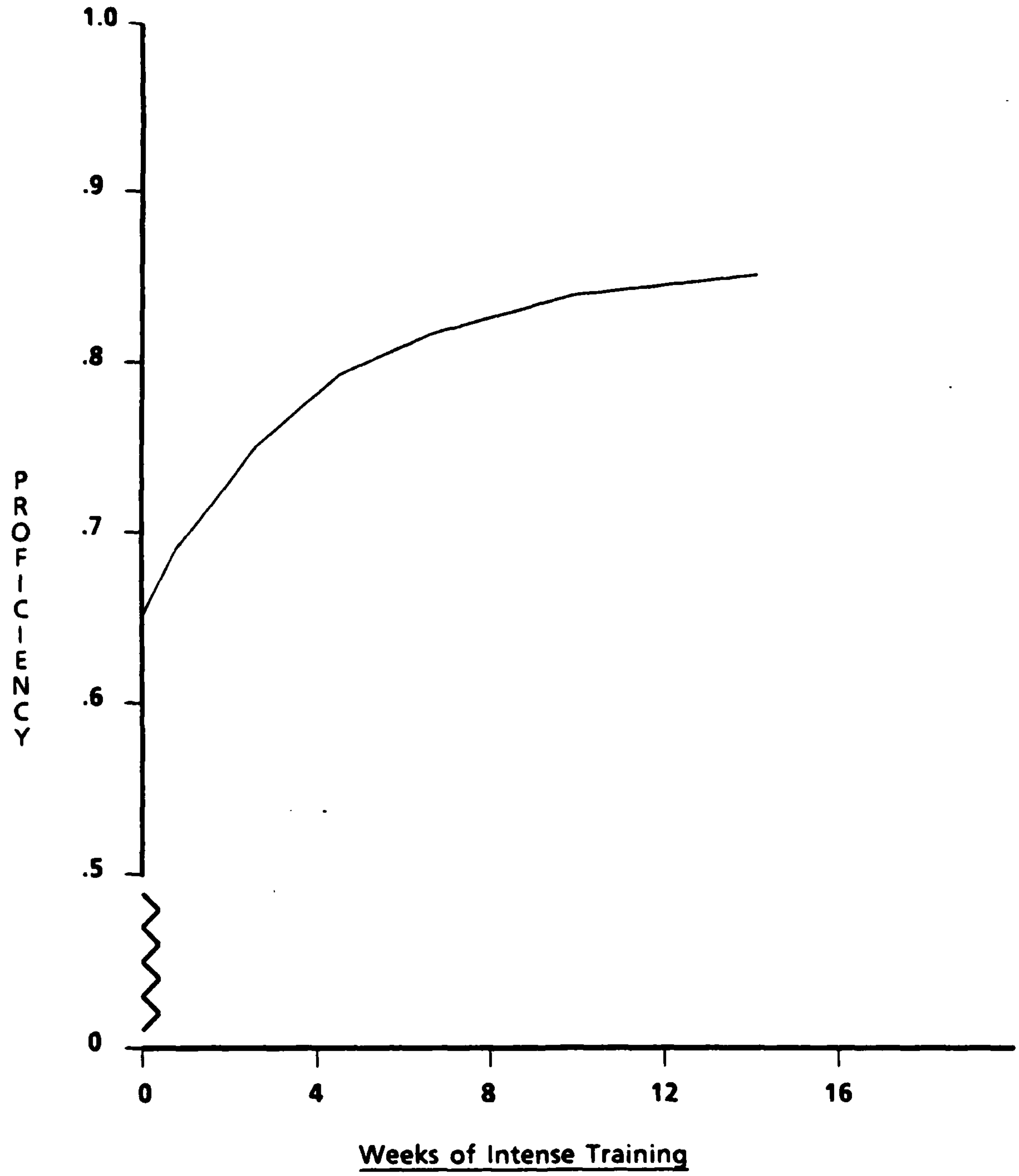


Figure B-25. Predeployment Proficiency Training

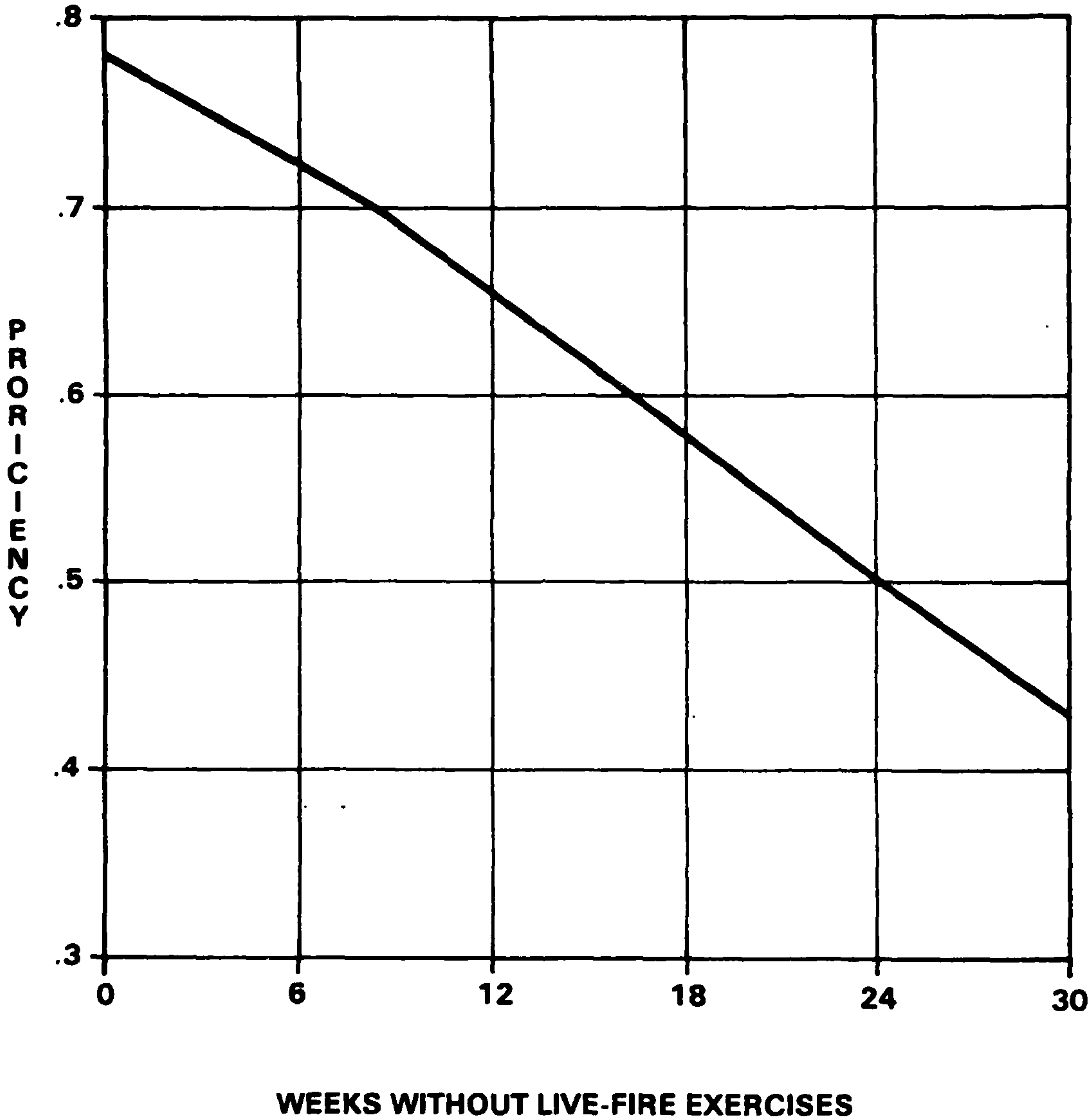
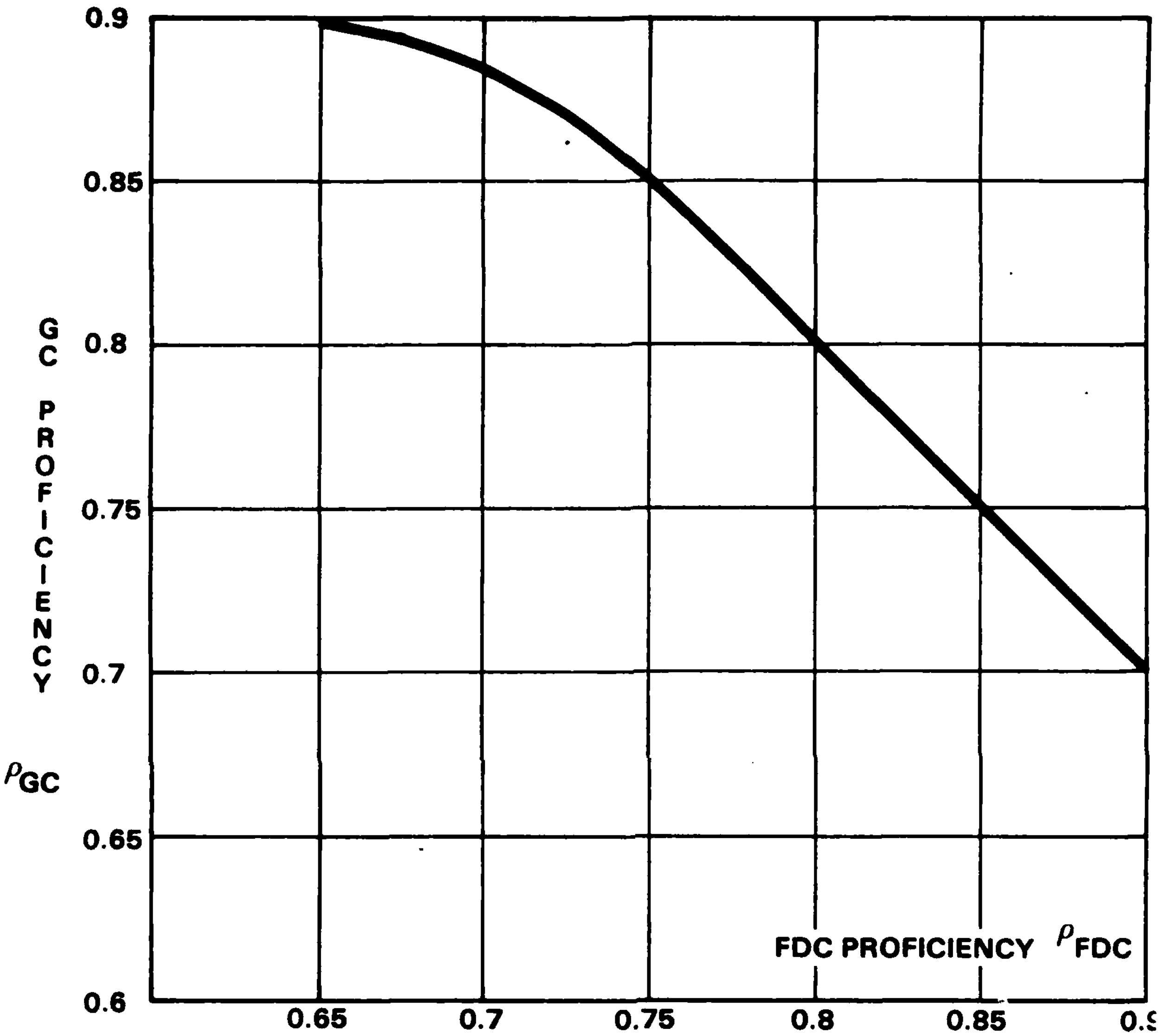
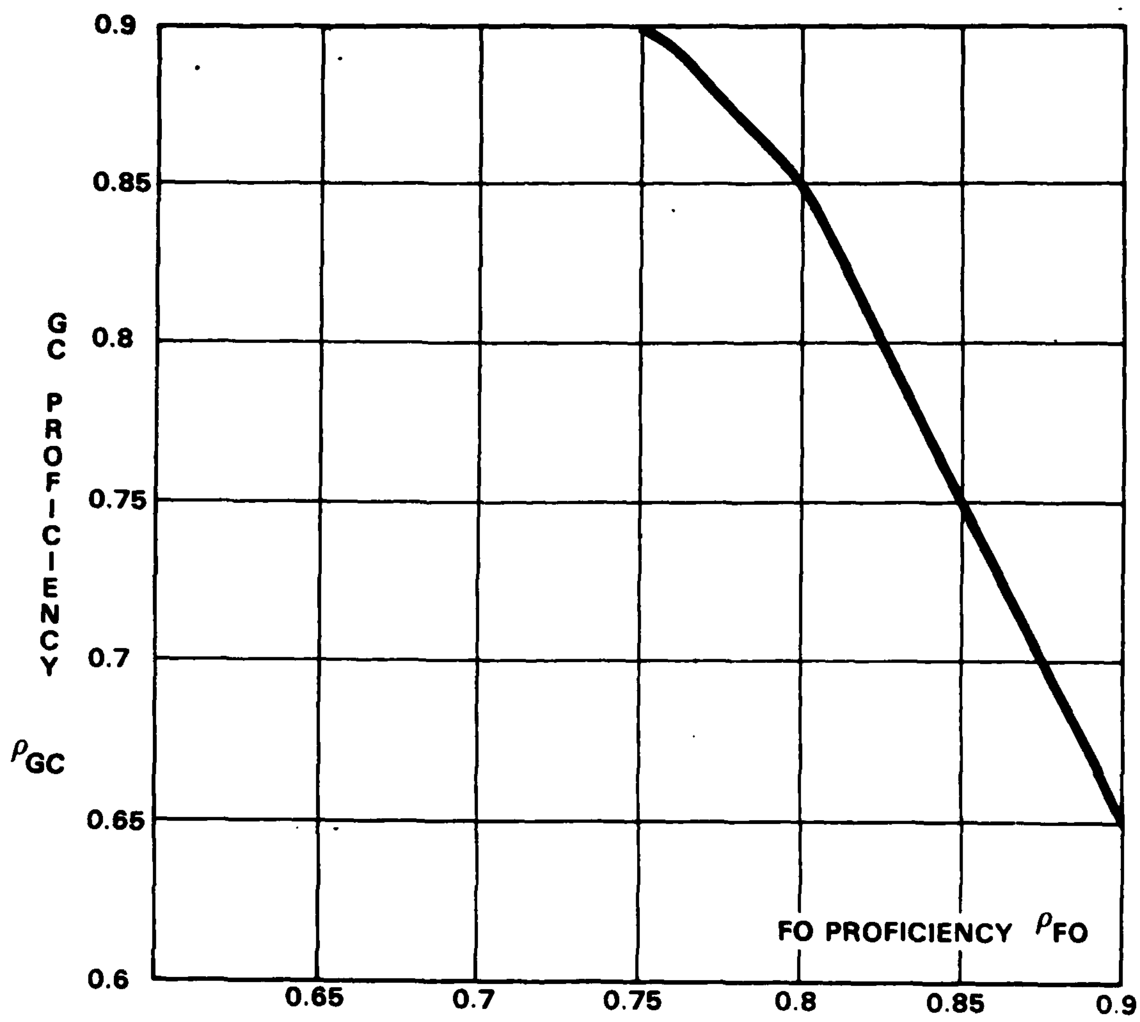


Figure B-26. Battery Proficiency Decay



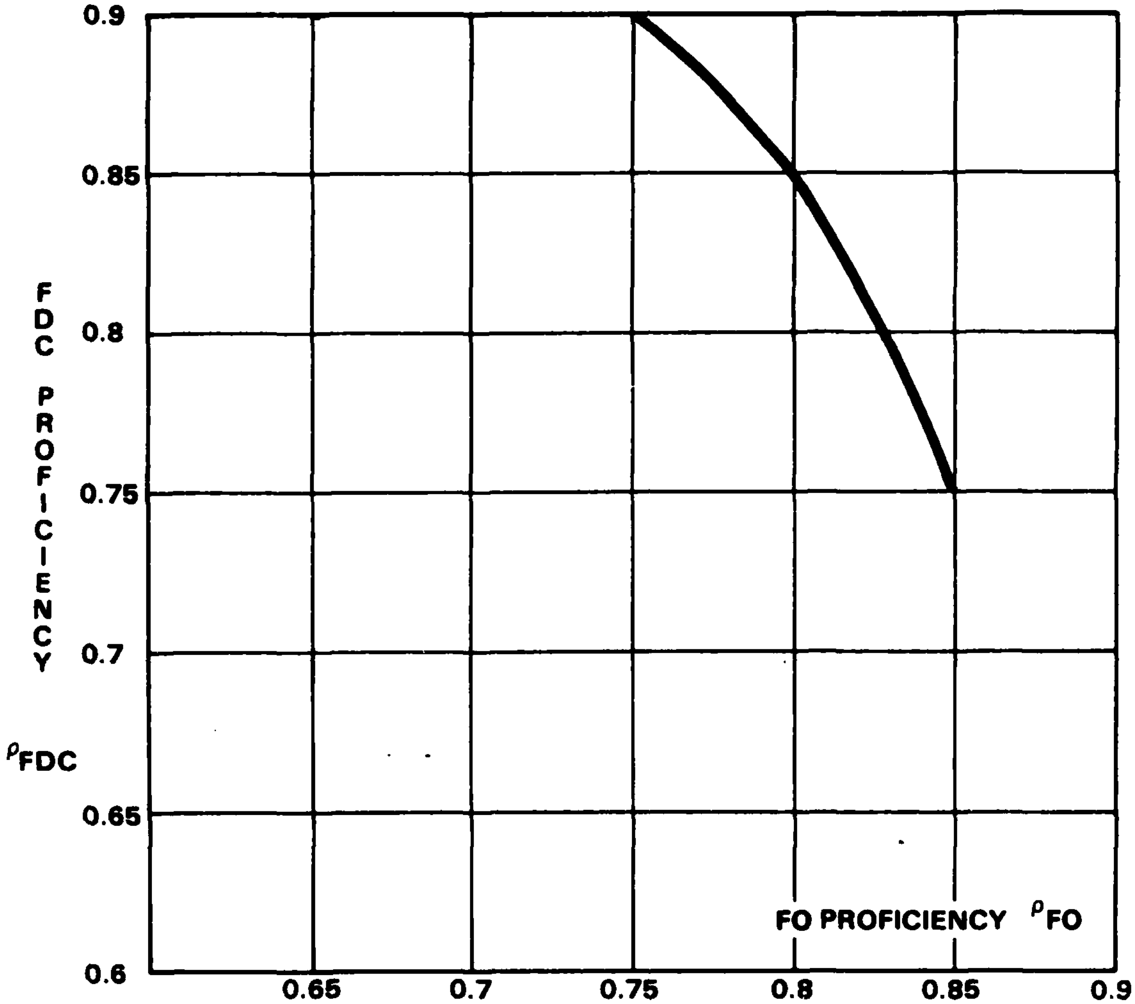
NOTES: 1. BATTERY PROFICIENCY FIXED AT 0.75.
2. FO PROFICIENCY FIXED AT 0.85.
3. PLOT OF THE RELATION $\Psi(0.85, \rho_{FDC}, \rho_{GC}) = 0.75$.

Figure B-27. Level Curve For GC, FDC Proficiency Given Fixed Battery and FO Proficiency



NOTES:
1. **BATTERY PROFICIENCY FIXED AT 0.75.**
2. **FDC PROFICIENCY FIXED AT 0.85.**
3. **PLOT OF THE RELATION** $\Psi(\rho_{FO}, 0.85, \rho_{GC}) = 0.75$

Figure B-28. Level Curve for GC, FO Given Fixed Battery and FDC Proficiency



NOTES: 1. BATTERY PROFICIENCY FIXED AT 0.75.
2. GC PROFICIENCY FIXED AT 0.85.
3. PLOT OF THE RELATION $\Psi(\rho_{FO}, \rho_{FDC}, 0.85) = 0.75$

Figure B-29. Level Curve for FDC and FO, Proficiency; Given Fixed Battery and GC Proficiency for FOs. For example, a policy which would keep FOs in the OP might accomplish this at no extra ammo cost.

ANNEX C

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TAB A-1

TANK GUNNERY QUESTIONNAIRE

TANK GUNNERY QUESTIONNAIRE

Personal Data

1. Name ______________________________

2. Rank ______________________________

3. What is your current position? ______________________________

4. How many years have you been in the USMC? ______________________________

5. What experience have you had in tank gunnery? Please describe jobs you have had conducting or supervising tank gunnery training to include how long you served in the job and briefly what the job entailed.

6. Briefly list your military assignments below:

Date From	Date To	Position	Unit/Location	Brief Job Description

M60 TANK TRAINING AMMUNITION REQUIREMENTS QUESTIONNAIRE

A. INTRODUCTION

The Marine Corps Development and Education Command has commissioned a study of training ammunition requirements for crew-served weapons. This questionnaire, which deals with the M60 tank, is one of a number being sent to selected individuals with a knowledge of training in particular weapons. Its purpose is to obtain judgement on how variations in the use of full caliber and subcaliber ammunition, and simulators, affects the level of proficiency of M60 crews. The results of the questionnaire will be used along with data from other sources to assess required training ammunition use rates. A review system will then be established to check the results in practice. The data, to be obtained from routine Marine Corps training, will confirm the results of the current study or indicate changes needed to ensure proficiency.

The questions are designed to obtain your best estimate of the effect on proficiency of different levels of ammunition use. Different training strategies are described in terms of the combination of full - caliber and subcaliber ammunition, and the amount of simulator training. We also ask that you provide separate answers for crews attempting to qualify for the first time, and crews who have qualified previously. Please read each question carefully to be sure you are considering all the factors involved.

B. QUESTIONS

1. Expected Crew Test Results

We would like to have your estimate of the proportions of crews falling into the ratings of distinguished, superior, qualified, and unqualified under different conditions. Figures 1.a and 1.b display different sets of training cases based on FM 17-12.

The cases differ in the amount of simulation used prior to crew training (pre-table and Tables I-V), and the amount of subcaliber ammunition substituted for full caliber in Tables VI, VII and VIII live fire. Zero confirmation is assumed to be conducted with full caliber ammunition.

Figure 1.a asks for performance estimates for crews qualifying the first time. Figure 1.b asks for the estimates for crews that have qualified at least once before.

The categories of qualification are based on the crew performance in Table VIII as follows:

Qualification Category	% of Maximum Table VIII Score
Distinguished	90 or better
Superior	80 or better
Qualified	70 or better

Please indicate in the blank spaces on the right half of Figure 1.a what percentage of crews qualifying for the first time that you would expect to achieve the qualifications indicated for each training-strategy case. For example, consider case 1.1 following the first training strategy which uses no simulation training and fires full caliber (F) live fire for zero confirmation (ZC), Table VI, Table VII, and Table VIII, a total of 162 rounds of ammunition per crew. In the blanks to the right of case 1.1 indicate what percentage of gun crews you would expect to achieve 90% or better (Distinguished), 80-89% (Superior), 70-79% (Qualified) and less than 70% (Unqualified). Note that the total of the numbers you have entered on the four blank spaces should equal 100. Now, consider case 1.2 which follows the same training strategy but substitutes subcaliber (SC) training for Table VI, reducing the amount of full caliber ammunition to 122 rounds per crew. Again on the four spaces to the right, indicate your estimate of the percentage of gun crews in each category of achievement. Continue the process for the remaining cases. Note that case 1.3 substitutes subcaliber firing for Tables VI and VII, and that cases 1.4, 1.5, and 1.6 are the same as case 1.1 except for the total amount of full caliber live ammunition per crew which is changed by factors of 1/3, 2/3 and 3/2. Strategy 2 calls for a mix of 30% simulation and 70% subcaliber in crew training and firing Tables I-V. Each case under this strategy (2.1, 2.2, and 2.3) is changed by substituting subcaliber firing in Tables VI and VII as indicated. Strategy 3 uses simulators in 90% of the crew training for pre-table and Tables I-V, and the cases are changed in the same manner as strategies 1 and 2. After filling all blanks on Figure 1.a, proceed to Figure 1.b and complete in the same manner, except your estimates should be based on expected results of requalification tests for crews that have previously qualified.

STRATEGY	CASE	TANK GUNNERY TEST (MAIN GUN) TABLE ZC	VI	VII	VIII	ANNUAL AMMO REQ/CREW	EXPECTED RESULTS FROM TABLE VIII (% OF CREWS ACHIEVING QUALIFICATION CATEGORY) DISTINGUISHED (90-100%)***	SUPERIOR (80-89%)	QUALIFIED (70-79%)	UNQUALIFIED (LESS THAN 70%)
1. SUB-CAL (NO SIMULATION) (M55, BREWSTER, TELFARE, TSV)	1.1	F	F	F	F*	162				
	1.2	F	SC*	F	F	122				
	1.3	F	SC	SC	F	76				
	1.4	F	F	F	F	108				
	1.5	F	F	F	F	54				
	1.6	F	F	F	F	243				
2. MIXED (30% SIMULATION) (M55, BREWSTER, TELFARE, TSV, PERCEPTRONICS)	2.1	F	F	F	F	162				
	2.2	F	SC	F	F	122				
	2.3	F	SC	SC	F	76				
3. SIMULATION (90% SIMULATION) (TELEFARE, TSV, PERCEPTRONICS, DETRAS)	3.1	F	F	F	F	162				
	3.2	F	SC	F	F	122				
	3.3	F	SC	SC	F	76				

* F = FULL CALIBER; SC = SUBCALIBER.
** 2 GUNNERY PROGRAMS, 1 TABLE IX PER YEAR.
*** % OF MAXIMUM SCORE

Figure 1.a. First Qualification Test Program

STRATEGY	CASE	TANK GUNNERY TEST (MAIN GUN) TABLE ZC	VI	VII	VIII	ANNUAL AMMO REQ/CREW**	EXPECTED RESULTS FROM TABLE VIII (% OF CREWS ACHIEVING QUALIFICATION CATEGORY) DISTINGUISHED (90-100%)***	SUPERIOR (80-89%)	QUALIFIED (70-79%)	UNQUALIFIED (LESS THAN 70%
1. SUB-CAL (NO SIMULATION) (M55, BREWSTER, TELFARE, TSV)	1.1	F	F	F	F*	162	______	______	______	______
	1.2	F	SC*	F	F	122	______	______	______	______
	1.3	F	SC	SC	F	76	______	______	______	______
	1.4	F	F	F	F	108	______	______	______	______
	1.5	F	F	F	F	54	______	______	______	______
	1.6	F	F	F	F	243	______	______	______	______
2. MIXED (30% SIMULATION) (M55, BREWSTER, TELFARE, TSV, PERCEPTRONICS)	2.1	F	F	F	F	162	______	______	______	______
	2.2	F	SC	F	F	122	______	______	______	______
	2.3	F	SC	SC	F	76	______	______	______	______
3. SIMULATION (90% SIMULATION) (TELEFARE, TSV, PERCEPTRONICS, DETRAS)	3.1	F	F	F	F	162	______	______	______	______
	3.2	F	SC	F	F	122	______	______	______	______
	3.3	F	SC	SC	F	76	______	______	______	______

* F = FULL CALIBER; SC = SUBCALIBER.
** 2 GUNNERY PROGRAMS, 1 TABLE IX PER YEAR.
*** % OF MAXIMUM SCORE

Figure 1.b. Requalification Test Program

2. <u>Expected Platoon Test Results</u>

We would like your estimates of platoon performance in Table IX as a function of ammunition usage. Figure 2 describes combinations of subcaliber and full caliber, and different levels of full caliber with no subcaliber. In the spaces provided on the figure, please indicate for each case the percentage of tank platoons you would expect to achieve each of the qualification categories. The categories correspond to the same percentage of maximum score as for tank crews, e.g., "Distinguished" applies to a score of 90 percent or better. Again, your totals for each case should equal 100.

3. <u>Expected Variations in Scores</u>

It is important to know the uncertainty associated with your estimates. The two following questions address the issue.

a. What variation in the percentage of crews in each category would you expect? ± _____ percent.

b. Would this variation apply to all the scores you listed in Figures 1 and 2? ______ (Yes/No). If "No", please indicate in the following space how the variation would differ among the training cases.

CASE	TABLE IX AMMO USE	EXPECTED PLATOON TEST RESULTS			
		Distinguished (90-100%)	Superior (80-89%)	Qualified (70-79%)	Unqualified (Less than 70%)
1	All full caliber (96F)*	______	______	______	______
2	1/3 subcaliber (32 SC/64F)	______	______	______	______
3	2/3 subcaliber (64 SC/32F)	______	______	______	______
4	2/3 full caliber (64F)	______	______	______	______
5	1/3 full caliber (32F)	______	______	______	______
6	3/2 full caliber (144F)	______	______	______	______

* Number of rounds; F = full caliber; SC = subcaliber.

Figure 2. Expected Platoon Test Results

4. The Effect of Turbulence on Crew Performance

Turnover within crews, receipt of new equipment and other turbulence factors affect crew proficiency. Considering the following cases of crew make-up and using training strategy case 1.1 with subcaliber (zero simulation) preliminary training and all full caliber crew training (Tables VI-VIII), please show the results in the table below that you would expect for the following cases:

CASE		% OF CREWS IN EACH CATEGORY			
		Distinguished (90-100%)	Superior (80-89%)	Qualified (70-79%)	Unqualified (Less than 70%)
Case 1.	Crews that have been together and qualified for at least one full year.	______	______	______	______
Case 2.	Crews with one new member - the gunner.	______	______	______	______
Case 3.	New crews (at least 3 out of the 4 men new, including a new gunner).	______	______	______	______

How accurate do you consider these estimates? ± _____ %.

5. Impact of Crew Requalification

Assume tank crews have to continue testing until they qualify. If reductions of full caliber ammunition in the Tables increases the number of crews who do not qualify, the cost savings from reduced ammunition use might be lost in the process of retraining and retesting. Of the crews that fail on their first attempt to qualify each year, indicate your estimate of the proportion of crews requiring one, two or more attempts in order to become qualified:

a. One repeat _____%

b. Two repeats _____%

c. More than two _____%

6. <u>The Effect of Turbulence on Platoon Performance</u>

Turbulence will affect platoons as well as crews. Please show in the following table what results you would expect for different mixes of experienced and inexperienced crews in a platoon.

CASE		% OF PLATOONS IN EACH CATEGORY			
Experienced Crews	Inexperienced Crews	Distinguished (90-100%)	Superior (80-89%)	Qualified (70-79%)	Unqualified (Less than 70%
5	0	______	______	______	______
4	1	______	______	______	______
3	2	______	______	______	______
2	3	______	______	______	______
1	4	______	______	______	______
0	5	______	______	______	______

7. <u>Effect of Frequency of Crew Training</u>

TC 25-3 recommends one qualification and one sustainment program per year. We would like your estimate of the effect of changing the frequency of sustainment programs. Assume a training strategy case 1.1 with subcaliber preliminary training, i.e., zero simulation, and a nominal expenditure of full caliber ammunition for Tables VI-VIII. Please show in the table below the results you would expect for the following cases for tank crews that have already qualified:

Case 1: A sustainment program conducted every three months after the qualification program. (4 per year)

Case 2: A sustainment program conducted every six months after the qualification program. (2 per year)

Case 3: A sustainment program conducted every nine months after the qualification program. (1.3 per year)

Case 4: A qualification program one year after a successful qualification, with no sustainment programs in between. (None)

CASE	% OF CREWS IN EACH CATEGORY: Distinguished (90-100%)	Superior (80-89%)	Qualified (70-79%)	Unqualified (Less than 70%)
1 (Every 3 Months)	______	______	______	______
2 (Every 6 Months)	______	______	______	______
3 (Every 9 Months)	______	______	______	______
4 (None)	______	______	______	______

8. Effect of Frequency of Platoon Training

This question is the same as 7, but applies to platoons. The cases are the same as listed in Question 7.

CASE	% OF PLATOONS IN EACH CATEGORY			
	Distinguished (90-100%)	Superior (80-89%)	Qualified (70-79%)	Unqualified (Less than 70%)
1 (Every 3 Months)	______	______	______	______
2 (Every 6 Months)	______	______	______	______
3 (Every 9 Months)	______	______	______	______
4 (None)	______	______	______	______

TAB B-1

QUESTIONNAIRES

81mm Mortar Questionnaire

Part I General Instructions
Part II Standards of Proficiency
Part III Questionnaire for the 81mm Mortar Platoon Commander and or 81mm Mortar Section Sergeant.

Part I General Instructions

The Marine Corps Development and Education Command has commissioned a study of training ammunition requirements for crew served weapons including artillery and mortars. This questionnaire deals with mortars. You have been selected to respond to this questionnaire because of your recognized knowledge of training and performance in mortar weapons. The purpose of the questionnaire is to obtain your judgement on such issues as the contribution of live firing to section and platoon proficiency, the contribution of simulators and training devices to section and platoon proficiency, the frequency at which training should be conducted and the effects of personnel turnover and crew skill degradation on section and platoon proficiency.

This questionnaire has been prepared for the 81mm mortar Platoon Commander and or the 81mm mortar Section Sergeant. The questionnaire has been prepared for a limited number of personnel. Therefore your responses to the questions will have a significant impact on the results of the study.

Please read each question carefully and thoroughly consider your response. The nature of the subject material in this study is abstract. There are limited sources of "hard" verifiable data for this type of study. Your individual bank of experience is the best source of information and you have been selected for this questionnaire based on your experience and knowledge.

Many of the questions are complex and call for judgments to be made. A major theme of the questionnaire deals with the relationship of the "live firing" of ammunition to "proficiency" or the ability of a section or platoon to perform in an accurate and responsive manner. Section Sergeants and Platoon Commanders tend to have different standards of proficiency and to define proficiency in differing terms. For the purposes of uniformity we define "proficiency" in terms of accuracy and time. For any given mission, there are accuracy and time criteria or standards for each function.

These standards or criteria are taken from Marine Corps Order 1510.35 The Individual Training Standards (ITS) System Volume 1, Training objective for the Infantry Occupational Field 03, and from ARTEP 7-15. Most of the standards cited in the former reference are taken from FM 23-91.

These Standards are listed in Part II of the questionnaire. Please take time to review these standards before attempting to answer the questions.

For purposes of this questionnaire, if the section or platoon performs to the accuracy and time standards established for a given type of mission that section or platoon is 100% proficient. It passed the test and satisfied the criteria. If the section or platoon did not perform to both the accuracy and time standards established for a given type of mission, that unit failed and thus its proficiency in that mission is zero per cent proficiency.

The questionnaire addresses many subjects in terms of a per cent of proficiency. For purposes of this questionnaire, a section or platoon which is 80% proficient is one which performs its required functions within the accuracy and time criteria in 80% of the total missions fired. During a series of normal live firing exercises, it is anticipated that the section or platoon will fire a wide variety of missions (Adjust Fire, Registrations, Illumination, Smoke, and Fire For Effect missions).

Each type mission may have criteria for each section of the platoon and for the platoon as a unit. These are presented in Part II as previously noted. It is further assumed that in the course of a series of normal live firing exercises that certain types of missions such as "Adjust Fire" missions will be fired more frequently than other types such as "Smoke"; and that registrations will be fired more frequently than Illumination missions.

If a platoon live firing exercise consisted of 1 Registration, 6 Adjust Fire missions, 1 Illumination mission and 2 Fire for Effect missions (a total of 10 missions), the platoon proficiency and section proficiency would be measured by their ability to perform to the accuracy and time criteria for each type mission. If the platoon or section met the standards for both accuracy and time in the Registration mission, in 5 of the 6 Adjust Fire missions and in the 2 Fire for Effect missions and failed to meet the standard in 1 of the Ajust Fire missions and the 1 Illumination mission, the platoon or section satisfied the criteria in 8 of the 10 missions fired. Therefore its proficiency for that live firing exercise would be 80%.

Other questions in the latter portion of the questionnaire address the attainment and maintenance of proficiency in a specific type of mission.

Again, please consider the questions and your response carefully. Your cooperation and the information provided is sincerely appreciated.

Part II
Standards of Proficiency

Source: MCO 1510.35 Individual Training Standards (ITS) System, Volume 1, Training Objective for the Infantry Occupational Field 03.

MANIPULATE MORTAR FOR TRAVERSING AND SEARCHING FIRES

Conditions:

Given a mounted 81mm mortar laid on aiming posts with 2800 mils deflection and 1100 mils elevation, assistant gunner, and firing data in the form of an initial fire command for one traversing mission and one searching mission (number of rounds specified must be four). Gunner will prepare gun to traverse left or right but will not relay on aiming posts until fire command is given.

Standards:

1--Traversing Mission: Within 80 seconds, the gunner will insure sight is correctly set for elevation, command "FIRE" for each round, and cross-level and search (number of turns to be given in initial fire command). After the last round is fired, the mortar will be searched down/up the number of turns given in the fire command, cross-leveled and will be within 20 mils for elevation.

ENGAGE A TARGET USING FIRE WITHOUT AN FDC (DIRECT LAY AND DIRECT ALIGNMENT)

Conditions:

Situation 1--Acting as the gunner, given a mounted 81mm mortar (baseplate settled), HE ammunition, firing table, a target observable from the mortar positions, and an assistant gunner, ammo bearer, and squad leader.

Situation 2--Acting as the gunner, given a mounted 81mm mortar (baseplate settled) laid on a directional stake, HE ammunition, firing table, a defilade mortar position from which target cannot be seen, an assistant gunner, ammo bearer, and FO/squad leader.

Standards:

Situation 1--Direct lay method: Gunner, within 4 minutes, will engage a point type target at a range of 500 to 1000 meters using no more than 4 rounds.

Situation 2--Direct alignment method: Gunner, within 7 minutes, will engage an area target at a range of 1000 to 2000 meters using no more than 5 rounds.

ADJUST FIRE WITHOUT AN FDC, USING DIRECT ALIGNMENT

Conditions:

As a mortar squad leader acting as the forward observer for the mortar complete with crew, binoculars, compass, identifiable target, and designated OP position. (The OP position can be either within 100 meters of the mortar position or within 100 meters of the gun-target (GT) line.)

Standards:

Within 10 minutes, the observer must achieve effect on target within 5 adjustments. The round must land within 50 meters of an area target or 25 meters of a point target to achieve effect on a target.

FIRE A LADDER MISSION USING FIRE WITHOUT AN FDC (DIRECT ALIGNMENT)

Conditions:

Acting as the squad leader, given a mounted 81mm mortar complete, in a defilade position, mortar crew, a direction stake with mortar laid on it, an FO position with observable targets, and a firing table.

Standards:

Target will be taken under effective fire within 5 minutes.

FIRE A TRAVERSING MISSION USING FIRE WITHOUT AN FDC

Conditions:

Acting as the squad leader for an 81mm mortar, given a mounted 81mm mortar complete and laid for direct alignment in a defilade position, an FO position within 100 meters of the mortar, with observable targets and a firing table.

Standards:

Within 5 minutes place effective fire on a wide target using traversing fire.

ENGAGE A DEEP TARGET USING SEARCHING FIRE WITHOUT AN FDC

Conditions:

Acting as the squad leader, given a mounted 81mm mortar complete, in a defilade position, mortar crew, a direction stake with mortar laid on it, an FO position with observable targets, and a firing table.

Standards:

Target will be taken under effective fire within 5 minutes.

PREPARE FDC ORDER

Conditions:

Given a call for fire, plotted target, and a computer's record (DA Form 2399--R).

Standards:

Fill out the FDC order portion of the computer's record (DA Form 2399--R) within 2 minutes for the mission given.

PREPARE M16 PLOTTING BOARD FOR OPERATION AS AN OBSERVED CHART AND DETERMINE INITIAL FIRING DATA FOR MORTARS (PIVOT POINT)

Conditions:

Given an M15 plotting board, a computer's record form, range and direction to the reference point (RP), firing table (FT) 81-AI-3 or the card firing table packed with the ammunition, a referred deflection of 2800 mils., and a No. 2 pencils.

Standards:

Within 5 minutes, prepare the M16 plotting board and computer's record IAW FM 23-91.

PROCESS SUBSEQUENT FO CORRECTIONS USING M16 PLOTTING BOARD (PIVOT POINT)

Conditions:

Given an M16 plotting board prepared for operation for a registration mission, to include deflection scale and a first-round plot that is labeled and marked; firing tables; computer's record with heading and FDC order completed; No. 2 pencil; TA-312/PT; FO's call for fire; and three subsequent corrections.

Standards:

1. The M16 plotting board must have the registration point (RP) correctly labeled and marked and the computer's record must contain the following information without error:

a. Call for fire.

b. Initial fire command.

c. Observer corrections.

d. Subsequent commands.

e. Rounds expended.

2. Corrections must be computed and data recorded on computer's record within 1 minute after being received from the FO. All corrections must be within 1 mil with a 10 mil tolerance for deflection and 25 meters for range.

PREPARE M16 PLOTTING BOARD FOR OPERATION AS OBSERVED CHART (BELOW PIVOT POINT) AND MODIFIED OBSERVED CHART

ondition:

As the fire direction computer for an 81mm mortar, given an M16 plotting board, 1:50,000 map, tabular firing tables, overlay of company's area of responsibility to include mortar position, and referred deflection.

Standards:

1--Prepare the M16 plotting board as an observed chart (below pivot point) within 5 minutes and accomplish the following:

a. Determine direction of fire within 1 mil with a tolerance of 10 mils.

b. Determine mounting azimuth without error.

c. Superimpose referred deflection that corresponds to the mounting azimuth.

d. Plot all known locations of mortars, targets, and reference points without errors.

2--Prepare the M16 plotting board as a modified observed chart within 5 minutes and accomplish the following:

a. Determine grid intersection.

b. Establish a coordinate system which represents all of the company's area of responsibility.

c. Plot location of mortars accurately to within 10 meters (8-digit coordinates); targets and reference point accurately to within 100 meters (6 digit coordinates).

d. Determine direction of fire within 1 mil with a tolerance of 10 mils.

e. Determine the mounting azimuth without error.

f. Superimpose the referred deflection that corresponds to the mounting azimuth.

PROCESS SUBSEQUENT FO CORRECTIONS USING M16 PLOTTING BOARD AS A MODIFIED OBSERVED CHART

Conditions:

Given an M16 plotting board prepared for operation as a modified observed chart, to include coordinate system; deflection scale; mortar and reference point plotted; firing tables; computer's record with heading and FDC order completed No. 2 pencil; FO's call for fire; and three subsequent corrections.

Standards:

1--Determine deflections to the nearest 1 mil, with a 10-mil tolerance.

2--Determine range to the nearest 25 meters.

3--Convert range to the correct charge and elevation.

4--Record rounds expended without error.

DETERMINE DATA FOR SHEAF ADJUSTMENTS

Conditions:

Given a section with the base mortar (No.2) registered, FDC equipment, and a request for sheaf adjustment.

Standards:

Determine firing data for sheaf adjustment to include:

1--Deflections to the nearest 1 mil with a 10-mil tolerance.

2--Range to the nearest 25 meters with a 25-meter tolerance.

3--Converting determined range to the correct charge and elevation.

DETERMINE DATA FROM RE-REGISTRATION AND APPLICATION OF CORRECTIONS

Conditions:

Given a registration point and a directive to re-register and to determine the corrections to apply, FDC equipment, and firing data sheet.

Standards:

Determine firing data for re-registration and apply corrections to include:

1--Determining deflections to the nearest 1 mil tolerance.

2--Determining range to the nearest 25 meters with a 25-meter tolerance.

3--Converting range to correct charge and elevation.

4--Replotting target locations.

5--Posting corrections to firing data sheet.

DETERMINE FIRING CORRECTIONS

Conditions:

Given the altitude of mortar position and target, chart deflection, chart, range, adjusted deflection, and adjusted range.

Standards:

Determine correction to include:

1--Altitude correction within 1 meter.

2--Range difference to nearest 25 meters.

3--Range correction factor (RCF) to within 1 meter.

4--Deflection correction to within 1 mil.

Source: ARTEP 7-15

TASK

Fire registration and confirm/adjust a parallel sheaf.

Adjust final protective fire (FPF).

Prevent enemy observation of friendly movement.

CONDITIONS

An FO is directed to adjust a registration using the base mortar and adjust the remaining two mortars parallel to the base mortar. FDC provided current metro message.

Another FO is given coordinates of an assigned FPF not more than 200 meters forward of friendly troops.

The FO effects advance coordination with the FDC and plans a smoke screening mission to conceal the movement of a covering force. One minute of obscuration is required.

STANDARDS

Platoon/section adjusts and records firing data within 12minutes. Last adjusting round impacts within 50 meters of the desired registration point. Subsequently, parallel sheaf adjustments are completed within 12 minutes.

Adjustments are completed within 20 minutes and final adjusting round impacts within 50 meters of assigned target.

Platoon/section establishes an effective screen within 12 minutes after the target is identified by the FO and maintains the screen for 1 minutes.

TASK

Engage an area target.

Shift fires to an area target.

Fire final protective fire.

Engage an area target.

CONDITIONS

An area target representing a Squad-size enemy reconnaissance patrol is identified.

Immediately after the above FFE rounds impact, a target representing a halted enemy scout vehicle is identified within 400 meters of the target previously engaged.

A target representing a survey team is located within transfer limits of the registration point by the FO using polar plot method.

TASK

Conduct MPI registration.

CONDITIONS

The registration is conducted by observers.

TRAINING/EVALUATION STANDARDS

Registration corrections are computed and recorded within 15 minutes using not more than 11 rounds.

TASK

Provide battlefield illumination.
Fire illumination w/coordinated HE.

CONDITIONS

FO calls for and adjusts illumination over suspected movement.

Same target as previous illumination mission. Enemy observed under illumination.

TRAINING/EVALUATION STANDARDS

Platoon/section adjusts and records firing within 12 minutes. Last adjusting round illuminates the target area and burns out as it reaches the ground. Continuous illumination is maintained for 2 minutes.

Platoon/section fires first illumination round witn 12 minutes. Coordinated HE is fired beneath illumination. Unit goes into FFE within 5 minutes.

STANDARD OF GRADING TECHNICAL DATA:

A. Accuracy of Observer's Initial Data (distance observer's initial data plots from target).

Observer-Tgt Dist 3,000 m or less	OT Dist in excess of 3,000 m	Rating
0-400 m ------	0-700 m ------	Sat
over 400 m ------	over 700 m ------	Unsat

B. Speed of Adjustment* (minutes).

0-15 -------------------------------- Sat
over 15 -------------------------------- Unsat

*Speed of Adjustment:

Time begins when observer identifies target and stops when all guns are ready to fire for effect.

Time is determined by subtrating safety time and total time of flight for all volleys in adjustment from overall time.

C. Reaction Time for Final Protective Fire. Time after mission received at FDC (minutes).

0-2 ---------------------------------- Sat
over 2 ---------------------------------- Unsat

D. Effects[1]. Accuracy of fire for effect will be graded on individual rounds landing inside the target rectangle as defined below:

Width (perpendicular to the line of fire)	Platoon front or 100 meters (whichever is less) + 8 probable deflection errors + number of meters subtended by an angle of 3 mils at the mortar target range.[2]
Depth	30 meters + 8 probable range errors.

[1]On "adjust fire" missions, it is possible for an observer to follow proper observed-fire procedures and still go into fire for effect up to 30 meters from the target. This is provided for as follows:

a. When the plotted center of impact plots less than 50 meters radial distance from the location of the target, the center of the rectangle is placed over the center of impact, keeping the rectangle oriented in the same relationship to the mortar target line.

b. When the center of impact falls more than 50 meters from the target, the center of the rectangle is placed on the center of impact line 50 meters from the surveyed location of the target, keeping the rectangle oriented in the same relationship to the mortar target line.

[2]This value compensates for the allowable error in laying the tubes and reading chart deflection.

E. Rating for Rounds Inside Prescribed Rectangle.

	Number of Weapons Firing			
Rating	4	3	2	1
Sat	3	2	1	1
Unsat	Under 3	Under 2	Under 1	Under 1

Part III

Questionnaire for the 81mm mortar Platoon Commander and 81mm mortar Section Sergeant.

1. Please indicate the type(s) of mortar units you have served with, the billet in which you served and the length of time in each billet.

   Type Unit   Number of Months   Billet

2. You are currently serving in what billet?

3. How long has it been since you served in either the billet of mortar Platoon Commander or mortar Secion Sergeant? ________ Months

4. You will find that a great number of questions in this questionnaire deal with the subject of "proficiency". You will be asked to make judgments concerning "Proficiency" of the mortar section based on exposure to training including live fire training. In order to assist you, the term "proficiency" is based upon 2 elements, the ability to perform accurately and the ability to perform in a timely manner. Both elements must be present to be "proficient". The criteria for both accuracy and time in any type of mission is extracted from MCO 1510.35 Individual Training Standards and from ARTEP 7-15.

   For purposes of this questionnaire, a mortar section which is 80% proficient is one which is capable of performing the required tasks within the accuracy and time criteria in 80% of the total missions fired. If a mortar section fired 20 missions of a various mix of Adjust Fire, Registrations, Smoke, Illumination, etc., and satisfied the accuracy and time criteria in 16 of those missions, that mortar section would be considered 80% proficient. If the section satisfied the criteria in 18 of those 20 missions, the section would be considered 90% proficient.

   Please review the portions of Part II that relate to the mortar section with respect to the criteria for proficiency in various types of missions.

   A. Do you believe these standards are attainable and realistic? Yes________ No__________

   B. If any three mortars sections were selected at random throughout the Battalion and tested in one week using the proficiency criteria in Part II, how do you think the average section would be evaluated?

90-100% ______
81-90% ______
71-80% ______
61-70% ______
51-60% ______
below 50% ______

How do you think the best of the three sections would be evaluated?

90-100% ______
81-90% ______
71-80% ______
61-70% ______
51-60% ______
below 50% ______

5. In your experience please address the following questions:

A. Estimate the average number of days per month that your mortar section participates in live fire training. ______ days per month period.

B. Estimate the number of live rounds expended by the mortar section on the average live firing day. ______ # rounds per firing day

C. Based upon your answers to questions 5 A, and B, do you believe that your mortar section fires more frequently or expends more live ammunition per shoot than other mortar sections of the Battalion. Check (1) (2) or (3) and check question subsecion if applicable.

( ) (1) No, my mortar section trains with live firing about as frequently as other mortar sections I have observed.

( ) (2) Yes my mortar section trains more frequently with live firing than the average mortar section. Check one:

( ) a. 10% more frequently
( ) b. 20% more frequently
( ) c. 30% more frequently
( ) d. 40% more frequently
( ) e. more than 40% more frequently

( ) (3) No my mortar section trains with live firing less frequently than the average mortar section. Check one:

( ) a. 10% less frequently
( ) b. 20% less frequently

( ) c) 30% less frequently
( ) d) 40% less frequently
( ) e) more than 40% less frequently

Skill Learning and Degradation

While it is recognized that many factors may tend to degrade the proficiency of the mortar section, two major factors are skill degradation and personnel turbulence or the turnover of personnel within the section. The following questions relate to the training situation where there is no turnover of personnel within the section for a period of 6 months.

6. Assume that your section had three experienced squad leaders but that all other mortar personnel recently arrived from FST. Given the normal amount of classroom instruction, instructions on the mortar and mortar drill, how long would you expect it would take before the following squads were prepared to participate in a live firing exercise?

1 squad in ___ months
2 squads in ___ months
3 squads in ___ months

7. After their first live firing exercise of 1 to 2 firing days, what would you expect their proficiency to be, based on the standards stated in Part II?

____10% proficient
____20% proficient
____30% proficient
____40% proficient
____50% proficient
____60% proficient
____70% proficient
____80% proficient
____90% proficient
____100% proficient

8. What kinds of problems would cause the section proficiency to be less than the required standard. Fill in the following blocks as appropriate. Mark 1 for the most important problem, 2 for the problem second in importance, 3 4 5 etc in order of declining importance. Mark 0 if the block presents no problem

____ Individual lack of knowledge of the mortar
____ Individual lack of knowledge of procedures relating t his job.
____ Individual inability to apply correct procedures to t required degree of accuracy
____ Individual inability to apply correct procedures with the required time
____ Individual inability to apply accurate and timely procedures in conjunction with other members of the squa
____ other (specify)

9. The "all new" section (3 squads) now has completed one live firing exercise of 1 or 2 days. Instruction on the mortar and mortar drill is conducted until the next live firing exercise, a period of time in accordance with your answers to question 5. A second live firing exercise is held and your section participates. At the conclusion of the second live firing exercise, how would you rate their proficiency.

____10% proficient
____20% proficient
____30% proficient
____40% proficient
____50% proficient
____60% proficient
____70% proficient
____80% proficient
____90% proficient
____100% proficient

10. What kinds of problems would cause the section proficiency to be less than the required standard. Fill in the following blocks as appropriate. Mark 1 for the most important problem, 2 3 4 5 in order of importance. Mark 0 if the block presents no problem.

____ Individual lack of knowledge of the mortar
____ Individual lack of knowledge or procedures relating to his job
____ Individual inability to apply correct procedures to required degree of accuracy
____ Individual inability to apply correct procedures within required time
____ Individual inability to apply accurate and timely procedures in conjunction with other members of the squad
____ other (specify)

11. How would you anticipate that section proficiency would improve in subsequent live firing exercises conducted at approximately the same time interval as stated in your answer to question 5? Mark an X in the appropriate line.

Proficiency	Live Firing Exercise 3rd	4th	5th	6th	7th	8th
10%	___	___	___	___	___	___
20%	___	___	___	___	___	___
30%	___	___	___	___	___	___
40%	___	___	___	___	___	___
50%	___	___	___	___	___	___
60%	___	___	___	___	___	___
70%	___	___	___	___	___	___
80%	___	___	___	___	___	___
90%	___	___	___	___	___	___
100%	___	___	___	___	___	___

12. Referring to your response to question 11, if 6 squads of all new crews were randomly selected for evaluation after 2 live firing exercises, would you expect the average proficiency to agree with the proficiency levels noted in question 11?

_____Yes

_____No, the average section would be
    _____10% more proficient
    _____20% more proficient
    _____30% more proficient

_____No, the average section would be
    _____10% less proficient
    _____20% less proficient
    _____30% less proficient

13. If 6 mortar squads were randomly selected and evaluated, the best squad would be _____% more proficient than the average squad: the worst squad would be _____% less proficient than the average squad.

14. Assume that your squad section were composed of typical marines who had been participating in classroom instruction, instruction on the mortar, ect, and had been firing "live" fire to the degree you indicated in your answer to question 5. Could you evaluate the proficiency of your squads or sections without observing them in live firing. Yes_______ No _________

15. Referring to question 14, how does live firing effect section proficiency? Check the appropriate block.

Block 1	___	Live firing does not materially effect proficiency
Block 2	___	Live firing simply validates the proficiency achieved in non firing training. It demonstrates what we already are capable of doing
Block 3	___	Live firing adds only a degree of realism to training. It is more exciting but does not effect proficiency.
Block 4	___	Live firing directly effects proficiency in a material way.

16. In the "fire for effect" phase of an adjust fire mission, the accuracy of the firing can be measured by the section or platoon firing one round per mortar. Do you feel that firing more than one round per mortar in effect increases the proficiency of the mortar personnel? Yes _________ no_________

Please explain your response:

17. Based on your experience, how frequently does the average platoon or section fire more than a one round per mortar in the "Fire for Effect" phase of an "Adjust Fire" mission?

_____ never
_____ once in about 20 or more missions
_____ once in about 10 missions
_____ once in about 5 missions
_____ every other mission
_____ every mission

18. Let us assume that your section has been training and participating in live firing at the rate indicated in your answer to question 5 and that your section has achieved a 80% proficiency. For reasons beyond the control of your unit, no live firing is possible for a period of 3 months. At the end of 3 months with no personnel turnover, your section participate again in a live firing experience.

A. How much of a decline in the proficiency of the section would you expect to experience. Proficiency would decrease from 80% to

_______ 75-79%
_______ 70-74%
_______ 65-69%
_______ 60-64%
_______ below 60%

B. In a random selection of 6 mortar squads, all of which were 80% proficient, the best squad would decline from 80% to

_______ 75-79%
_______ 70-74%
_______ 65-69%
_______ 60-64%
_______ below 60%

The worst squad would decline from 80% to

_______ 75-79%
_______ 70-74%
_______ 65-69%
_______ 60-64%
_______ below 60%

C. In reference to questions 18A and 18B, would the decrease in proficiency be due to:

Mark 1 2 3 4 in order of importance. Mark 0 if not a problem.

_____ squad personnel not working together as a team effort in the required time
_____ some squad personnel individually slow in applying current procedures
_____ some squad personnel individually making errors in procedure
_____ some squad personnel forgetting the correct procedures

D. Given the proficiency decrease stated in your respone to question 18A, how many additional live firing exercises at the rate specified in your answer to question 5 do you think would be required before the section again achieved a 80% proficiency?

_____ 1 more live firing exercise
_____ 2 more live firing exercises
_____ 3 more live firing exercises
_____ 4 more live firing exercises
_____ 5 or more additional live firing exercises

E. If the section fired twice as frequently as your answer to question 5, how many live firing exercises would be required to again achieve a 80% proficiency? Check the appropriate block.

_____ none, live firing not required
_____ 1 more live firing exercise
_____ 2 more live firing exercises
_____ 3 more live firing exercises
_____ 4 more live firing exercises
_____ 5 more live firing exercises
_____ 6 more live firing exercises
_____ 7 more live firing exercises
_____ 8 more live firing exercises
_____ more than 8

The following questions deal with the subject of <u>personnel turnover</u> and its effect on the proficiency of the unit. Assume each squad has a Squad header, a Gunner (no. 1), Assistant Gunner (no. 2) and two Ammunition Handlers (Nos. 3 and 4).

19. What has been your experience with personnel turnover within your section(s)? In an average 6 months period, what is the average number of personnel <u>per squad</u> that would be lost through transfer, end of enlistment, reassignment, schools or for other reasons.

_____ none
_____ one
_____ two
_____ three
_____ four

Do you think this is representative of the average mortar section? Yes _____ No _____ a squad in the average section would lose _____ personnel in 6 months.

20. When you lose personnel, where do their replacements come from?

_____ % from non Trained personnel
_____ % from other trained personnel

21. If your section trained at the frequency described in questions 5 and were 90% proficient, do you feel that replacing 1 of each squads ammunition handlers in a 3 month period would cause a material drop in section proficiency? _____ No _____ Yes, proficiency would decrease from 90% to ______.

22. In reference to question 21, do you feel that the replacement of 2 ammunition handlers in each squad in a 3 month period would cause a material drop in sections proficiency? No____ Yes____ section proficiency would decrease from 90% to _______%.

23. In reference to question 21, how would you evaluate the loss of a

A. one gunner or assistant gunner in each squad in 3 months
____ no material effect
____ section proficiency would decrease from 90% to ___%

B. 1 of the 3 squad leaders in 3 months
____ no material effect
____ section proficiency would decrease from 90% to ___%

C. 2 of the 3 squad leaders in 3 months
____ no material effect
____ section proficiency would decrease from 90% to ___%.

24. By conducting non firing and live fire training at the usual interval (question 5) could you maintain the sections 90% proficiency?

A. How many months at this training rate would be required before your section could regain the 90% level of proficiency _____ mo.

B. If the frequency of live firing were increased 50%, how many months would be required before your section could regain the 90% level of proficiency? ______mo.

C. If you were required to regain 90% section proficiency within 45 days after the turnover of personnel, how many live firing days do you think your section would need? _____days.

D. Do you feel that section proficiency of 90% could be regained without live firing? Yes______ No_______

25. If your section was 90% proficient and trained on the frequency indicated in question 5,

A. How many personnel per squad could be replaced each month before the section proficiency decreased from 90% to 80%?

A. one per month
B. two per month
C. three per month
D. four per month

B. How many personnel per squad could be replaced each month before the section proficiency decreased from 90% to 70%?
Ans. ______personnel per squad per month.

26. If your section proficiency declined because of personnel turnover, how would you prefer to see training conducted to regain your sections 90% proficiency level. Mark 1. 2. 3 etc. in order of importance. If not applicable, leave blank.

____ provide special instruction to new personnel on the mortar.
____ conduct more mortar drill to enable new members to become familiar with squad and section.
____ conduct more live firing.

27. If your section normally participates in 2 days of live firing at least once per month, and you experience a turnover of personnel which reduces your section proficiency from 90%-70%.

A. How many months at this training rate would be required before your section could regain the 90% level of proficiency ____ mo.

B. If the frequency of live firing were increased to 3 days of live firing per month, how many months would be required before your section could regain the 90% level of proficiency? ____ mo.

C. If you were required to regain 90% battery proficiency within 45 days after the turnover of personnel, how many live firing days do you think your section would need? ____ days.

D. Do you feel that section proficiency of 90% could be regained without live firing? Yes _____ no _____

E. If the section proficiency dropped from 90% to 70% because of personnel turnover, how much of an improvement in proficiency could be anticipated without live firing?

____ Proficiency of 90% could be regained without live firing
____ Proficiency of 85% could be regained without live firing
____ Proficiency of 80% could be regained without live firing
____ Proficiency of 75% could be regained without live firing
____ Proficiency of less than 75% could be regained without live firing

The following questions effect the use of training simulations, simulators and training devices and their effect on unit proficiency.

28. What training devices have you had the opportunity to use? List devices
1)
2)
3)
4)
5)
6)

29. Which of these devices are available for use in your section or platoon?

30. As a tool for training personnel, what is your evaluation of current raining devices?
____ they are of very little value
____ they are of some value
____ they are of considerable value
____ they are very important in training personnel

31. In an average 22 day training month, approximately how many days are devoted to the following types of mortars training.
____ days of live firing training
____ days of training using training devices
____ days of training using mortar team drill
____ days of training using none of the above
____ days where no mortar related training is conducted

32. In referring to question 31 what breakdown in training would days are devoted to the following types of mortars training.
____ days of live fire training
____ days of training using training devices
____ days of training using mortar drill only
____ days of training using none of the above

33. What is your principal criticism of training devices if any. Mark ____ in order of importance. 1 most important, 2 next important, etc.
____ no criticism
____ they are not designed to effectively improve individual squad or section performance

____ they do not adequately measure the time aspect of squad or section performance
____ they do not adequately simulate the conditions of live firing
____ they are basically boring to use
____ they do not present a challenge to mortar personnel to learn

34. Let us assume that your section is not very proficient (50%) because of a heavy turnover of personnel. In 6 months your section will be evaluated using the standards in Part II. There will be no live firing exercisee until the evaluation is administered. You may use any type of non live firing training, simulator, devices, etc. How would you estimate the section would perform in live firing at the evaluation?

____ 91-100%
____ 81-90%
____ 71-80%
____ 61-70%
____ 51-60%
____ no better than 50%
____ below 50%

What devices or simulations would you use to attain that level. Explain.

35. Referring to question 34, suppose the evaluation were to be given in 3 months, instead of six months. With no live firing prior to the evaluation, how would you estimate the section/platoon would perform in the evaluation?

____ 91-100%
____ 81-90%
____ 71-80%
____ 61-70%
____ 51-60%
____ no better than 50%
____ below 50%

36. Do you feel that the answers to questions 34 and 35 would be different if you had more capable training devices? ____Yes ____No

37. What specifically do you desire to see in a training device that helps train your section or platoon? Explain:

38. Referring to question 34, what non firing training approaches would you use to attain the proficiency checked? Please make 1,2,3,4 etc. in order of importance.

____ training devices
____ mortar drill
____ classroom instruction
____ mortar drill in a field enviroment
____ instruction on the mortar

39. Which training devices do you find to be effective in training your personnel? List in order of importance.

40. Let us assume that the frequency of firing and the number of rounds fired in question 5 resulted in a certain level of proficiency measured in accordance with the standards stated in Part II.

A. If the live firing frequency were <u>decreased</u> by 1/2 on an annual basis and training devices were substituted, what effect would this have on section proficiency? Check one.

____ proficiency would remain about the same
____ proficiency would increase 10% to 20%
____ proficiency would increase more than 20%
____ proficiency would decrease 10% to 20%
____ proficiency would decrease more than 20%

B. If the live firing frequency remained the same but the number of live rounds used in each experience were decreased by 1/2 on an annual basis, and training devices were substituted, what effect would this have on section proficiency? Check one.

____ proficiency would remain about the same
____ proficiency would increase 10% to 20%
____ proficiency would increase more than 20%
____ proficiency would decrease 10% to 20%
____ proficiency would decrease more than 20%

41. Can you suggest an approach that would increase and/or maintain section proficiency at a high level with a reduction in the use of live ammunition? Explain:

42. How much of a reduction in live ammunition can be achieved can be achieved using the approach in Question 41?

43. Have you ever taken the MCCHES evaluation. ______Yes ____No

44. How well did you unit do? ______passed ________failed

There are many kinds or types of mortar missions which the section or platoon may be called upon to fire. The following type missions are examples.

Registration
Adjust Fire
Illumination
Coordinated illumination with HE
Smoke
Fire for Effect without adjustment

It is recognized that different methods of fire, different ammunition and fuzing combinations are associated with these missions. Let us assume that the mortar section has certain procedures to learn in order to properly conduct an "Adjust Fire" mission and that the learning of these procedures by the section present some degree of difficulty. Assume the section is 80% proficient in conducting an Adjust Fire mission.

45. Do you find the procedures used with a registration are more difficult for the mortar sections to learn than those used in the "Adjust Fire" procedure?

A. The precision registration procedure is
   ____ easier to learn than the "Adjust Fire" mission
   ____ about the same degree of difficulty as the "Adjust Fire" mission
   ____ slightly more difficult to learn than the "Adjust Fire" mission
   ____ materially more difficult to learn then the "Adjust Fire" mission
   ____ one of the most difficult of all firing missions

46. The illumination mission procedure is
- ____ easier to learn than the "Adjust Fire" mission
- ____ about the same degree of difficulty as the "Adjust Fire" mission
- ____ slightly more difficult to learn than the "Adjust Fire" mission
- ____ materially more difficult to learn than the "Adjust Fire"mission
- ____ one of the most difficult of all firing missions

47. The Coordinated Illumination/HE mission procedures are
- ____ easier to learn than the "Adjust Fire" mission
- ____ about the same degree of difficulty as the "Adjust Fire" mission
- ____ slightly more difficult to learn than the "Adjust Fire" mission
- ____ materially more difficult to learn than the "Adjust Fire" mission
- ____ one of the most difficult of all firing missions

48. The Smoke, HC mission procedure is
- ____ easier to learn than the "Adjust Fire" mission
- ____ about the same degree of difficulty as the "Adjust
- ____ slightly more difficult to learn than the "Adjust Fire" mission
- ____ materially more difficult to learn than the "Adjust Fire mission
- ____ one of the most difficult of all firing missions

49. The Fire for Effect mission procedure is
- ____ Easier to learn than the "Adjust Fire" mission
- ____ about the same degree of difficulty as the "Adjust Fire" mission
- ____ slightly more difficult to learn than the "Adjust Fire" mission
- ____ materially more difficult to learn than the "Adjust Fire mission
- ____ one of the most difficult of all firing missions

The following questions deal with the Forward Observation function with the 81mm mortars.

50. In the course of an average month of training within the battery, assuming 22 working days per month, how many days does the average mortar FO devote to the following:
- ____ days of live firing exercises
- ____ days of participation directly with the FDC in "dry run" missions
- ____ days of unit schools or instruction for the FO in FO techniques, mission responsibilities or matters directly related to the FO function
- ____ days of self taught instruction on FO subjects
- ____ days of training devices or simulations

____ days of other FO activities
____ days where other responsibilities commitments preclude any FO related training.

51. In referring to your response to question 50, suppose you had the decision of how training time could be allocated to better improve the FO proficiency. How would you allocate the training days in the cateories listed in question 50? Assume 22 working days in a month.

____ days of live firing exercises
____ days of participation directly with the FDC in "dry run" missions
____ days of unit schools or instruction for the FO in FO technique, mission responsibilities or matters directly related to the FO function
____ days of self taught instruction on FO subjects
____ days of training devices or simulations.
____ days of other FO activities
____ days where other responsibilities commitments preclude any FO related training.

Explain your reasons for the difference in allocation time.

52. If training days were allocated as you suggest in question 51, what kind of increase in proficiency would you expect that the average FO would experience over a 6 month period?

____ less than 10% increase
____ between 11% and 20% increase
____ between 21% and 30% increase
____ between 31% and 40% increase
____ between 41% and 50% increase
____ more than a 50% increase

53. When the FO is on the observation post (OP) participating in a live fire platton exercise, normally how many other FOs are present on the OP?

____ The FO conducting the mission is normally alone.
____ there is usually one other FO on the OP
____ there are usually two other FOs on the OP
____ there are usually three other FOs on the OP
____ there are usually more than three other FOs on the OP

54. If you were an FO present on the OP observing the performance of another FO conducting a live fire mission, do you believe your proficiency would benefit?
____ no
____ not materially
____ yes, there would be a material benefit
____ next to shooting the mission myself, the experience provides more benefit than other forms of instruction such as training devices, simulation, etc.

The following questions deal with the subject of live firing and its effect on FO proficiency. Some of the questions may appear to be self-evident; however, the questionnaire is attempting to isloate those FO functions which are procedural in nature and can be mastered without the use of live firing, those funcions which heavily depend on live fire as a "learning" vehicle.

55. One principal responsibility of the FO is to locate the target. Would you agree that an FO with normal T/E equipment, after locating himself and analyzing the terrain, can locate the target without firing?

Yes _____ No _____

56. Referring to question 55, in "rolling" to "hilly" terrain, how accurately would you expect the average FO to be capable of determining the locating of a stationary target approximately 3000 meters from the FO? The FO has binoculars, compass, 1/50,000 map.

_____ within 100 meters
_____ 100-200 meters
_____ 200-300 meters
_____ 300-400 meters
_____ more than 400 meters

57. Do you feel a terrain analysis requires live firing?

Yes _____ No _____

58. Given that you have determined the location of the target and transmitted the "Call for Fire" to the FDC for an "Adjust Fire" mission, do you belive the conduct of the adjustment phase of an "Adjust Fire" mission is a difficult procedure to master?

Yes _____ No _____

59. How many "Adjust Fire" type missions using live ammunition do you feel an FO must conduct in order to attain an 80% proficiency in this type mission.

_____ missions

60. Referring to question 59, approximately how many live fire "Adjust Fire" type missions per quarter (3 months) do you think an FO should conduc to maintain an 80% proficiency in this one type mission?

_____ per quarter

61. The FO requires a knowledge of the effects of various types of fuze and ammunition combinations in order to decide how to engage certain types of targets. Field manuals provide some guidance in this area. Obviously some live firing is required for the FO to see the effects in real life. Assume you, as the FO on an annual basis, personally oberved 1 mission each involving the use of HE w/PD, delay, PD superquick, Time, VT, WP, Smoke, Illumination. Do you need to see more than this number per year to retain this data in your memory?

Yes ______ No ______

62. If the answer to question 61 is "yes" how many times per year?

____ 2 times/year
____ 3-4 times/year
____ 5-6 times/year
____ more than 6 times/year

63. In the adjustment phase of a registration, do you find that the adjustment of the base mortar involves any different procedure than the adjustment phase of typical "Adjust Fire" mission?

Yes ______ No ______

If yes, please explain how the adjustment procedure differs.

64. Assuming you can conduct an "Adjust Fire" mission in a proficient manner,

A. how many live fire Registration missions must you conduct to attain an 80% proficiency in this type registration?
_____Missions

B. how many live fire Registrations must you conduct annually to maintain an 80% proficiency in this type registration.

65. Would you agree that the primary purpose of all types of registration missions is to obtain corrections which can be applied to subsequent missions? Some live firing is required to obtain these corrections. Do you as an FO derive any training benefit from the conduct of a live firing registration other than learning the procedures unique with each type registration?
_____ No
_____ Yes, please explain.

66. Have you ever conducted an illumination mission?
Yes ______ No_______

If Yes,
A. Are the procedures complicated?
Yes _____ NO _____

B. Do you believe there is any way to simulate this kind of mission without live firing?
Yes ______ No________
Briefly explain your answer.

67. How many live fire illumination missions must an average FO conduct to attain a proficiency of 80% in this type mission?
_______ illumination missions per year.

68. How many live fire illumination missions must an average FO conduct annually to maintain an 80% proficiency in this type mission? _______ illumination missions per year.

69. Have you ever conducted a coordinated illumination and HE mission?
______Yes ________No

A. Do you believe the procedures are complicated.
Yes ________ No________

B. Who do you think caries the heavier burden in the conduct of this mission?
FO _______

FDC________
Firing Battery_______

70. Assuming you are 80% proficient in conducting an illumination mission and are 80% proficient in conducting an "Adjust Fire" mission,

A. How many coordinated (Illumination and HE) missions must an observer conduct in order to attain 80% proficiency in conducting a coordinated mission? ________missions

B. How many corrdinated (Illumination and HE) missions must an observer conduct annually in order to maintain an 80% proficiency in conducting this type mission? __________missions per year.

71. Assuming you are 80% proficient in conducting an "Adjust Fire" type mission, how many live fire missions of the following types must an FO conduct to attain an 80% proficiency in each type and how many missions of each type must the FO conduct annually to maintain the 80% proficiency?

A. Smoke HC and/or WP
_____ missions to attain 80% proficiency
_____ missions per year to maintain 80% proficiency

B. Fire for Effect (without adjustment) using shell HE
_____ missions to attain 80% proficiency
_____ missions per year to maintain 80% proficiency

72. Name the kinds of missions that most FO find the most difficult to conduct.

73. Specifically, what makes these missions more difficult than others? Mark the appropriate blocks in order of importance.

_____ very complicated procedures for the FO
_____ very complicated coordination between the FO and the FDC
_____ these type missions are not fired frequently enough in routine firing exercises.
_____ these type missions are not practiced frequently enough in routine non-firing training

74. Over a period of three platoon/section live firing exercises of 1 to 2 days each in a 3 month period of time,

A. Approximately how many total missions would be fired?
______missions

B. Of these, how many would be registrations?
______missions

C. How many would be "Adjust Fire" missions?
Missions ______

D. How many would be illumination, or smoke?
______ Illumination
______ Smoke

E. How many non adjustment FFE missions would there be?
FFE missions ______

75. Let us assume that your proficiency as an FO attained an 80% level and that you continued to maintain the level by firing at the frequency indicated in your answer to question 6. For reasons beyond the control of the battery, assume that no live firing exercises are possible for a 3 month period. How would you think your overall proficiency as an FO would decline?

A. From the 90% proficiency level to approximately the ____% level.

B. It would not decline at all _____.

76. If 5 FOs were randomly selected within the battalion, all of which were 80% proficient and subjected to a 3 month period of no live firing, how would you think the effect on the FO proficiency would decline from the 80% proficiency level?

_____ of the 5 FOs would show no decline in proficiency
_____ of the 5 Fos would show a less than 10% decline in proficiency
_____ of the 5 FOs would show a 10-20% decline in proficiency
_____ of the 5 FOs would show a 21-30% decline in proficiency
_____ of the 5 FOs would show more than a 30% decline in proficiency

77. If at the end of a 3 month period of no live firing, the 5 randomly selected FOs in question 76 agin resumed live firing at the rate of 1-2 days per month,

A. How many months would it take for the average FO to regain his 80% proficiency level? _____months

B. How many months would it take for the one best qualified FO to regain his 80% proficiency level? ____months

C. How many months would it take for the one least qualified FO to regain his 80% proficiency level? _____months

78. In referring to question 77, if the frequency of live fire were increased 50% (1 1/2-3 days per month),

A. How many months would it take for the average FO to regain his 80% proficiency level? ______months

B. How many months would it take for the one best qualified FO to regain his 80% proficiency level? ______months

C. How many months would it take for the one least qualified FO to regain his 80% proficiency level? _______ months

79. If you were assigned the duties of a FO upon joining a mortar platoon, how many months would you expect to serve as FO until you were reassigned to a non-FO billet?
_______ months

80. When an experienced mortar FO has been replaced by a new FO, is there a noticeable effect on the overall proficiency. Section or Platoon.
Yes _______ No _______

81. Referring to question 80, if the answer was yes, would you attribute the change in proficiency to
_____ errors by the FO in basic knowledge
_____ errors by the FO in basic procedures
_____ slowness by the FO in applying the correct procedures
_____ lack of experience in coordinating with the FDC

82. Referring to question 81, how can this problem be most rapidly overcome?
_____ by more live firing exercises
_____ by more participation by the FO in FDC team drill
_____ by more schooling of the FO on accuracy and timeliness of procedures
_____ by more basic schooling

83. Referring to question 80,

A. With the new FO, how many months do you think it would take the section or platoon to regain its prior level of proficiency, assuming that live firing exercises of 1 to 2 days were conducted on a monthly basis? _______ months

B. With the new FO, how many months do you think it would take the section or platoon to regain its prior level or proficiency, assuming that live firing exercises at the rate of 2 to 4 days per month, (twice the rate of question 83A)? _______ months

C. Do you think the section or platoon proficiency could be regained without live firing?
Yes _______ No _______

If no, could any degree of proficiency be regained without live firing?
_______ Yes _______ No, probably _____ % of the unit proficiency could be regained without live firing

84. Have you seen any training device that provides the FO with an opportunity to learn?
Yes _____ No _____
What Device?

85. What characteristics would you like to see in a training device to improve FO proficiency? List:

86. What is your principal criticism of FO training devices? Mark in order of importance.

___ no Criticism
___ they are not designed to effectively improve FO performance
___ they do not adequately measure the accuracy of FO performance
___ they do not adequately measure the time aspect or responsiveness of FO performance
___ they do not present a challenge to the FO
___ they are basically boring to train with

87. Let us assume that the proficiency of all the Platoon FOs has declined to 50% because of a heavy turnover in FO personnel. In 6 months the platoon FOs will be evaluated using the MCCRES standards. There will be no live firing until the MCCRES is administered. You may use any type of non-live firing training (simulators, devices, drills, study) you desire.

A. How would you expect the average FO in the platoon would perform in live firing at the MCCRES evaluation? Proficiency is based on both accuracy and time criteria.
___ 91-100%
___ 81-90%
___ 71-80%
___ 61-70%
___ 51-60%
___ no better than 50%
___ below 50%

B. How well would you expect the most proficient FO to perform?
___ 91-100%
___ 81-90%
___ 71-80%
___ 61-70%
___ 51-60%
___ no better than 50%
___ below 50%

C. How well would you expect the least proficient FO to perform?
___ 91-100%

___ 81-90%
___ 71-80%
___ 61-70%
___ 51-60%
___ no better than 50%
___ below 50%

88. Referring to question 87, suppose the MCCRES evaluation were to take place in 3 months instead of 6 months with no live firing prior to MCCRES,

A. How would you expect the average FO in the battery would perform in live firing at the MCCRES evaluation?
___ 91-100%
___ 81-90%
___ 71-80%
___ 61-70%
___ 51-60%
___ no better than 50%
___ below 50%

B. How well would you expect the most proficient FO to perform?
___ 91-100%
___ 81-90%
___ 71-80%
___ 61-70%
___ 51-60%
___ no better than 50%
___ below 50%

C. How well would you expect the least proficient FO to perform?
___ 91-100%
___ 81-90%
___ 71-80%
___ 61-70%
___ 51-60%
___ no better than 50%
___ below 50%

89. In reviewing the various types of mortar firing missions, we are interested in your perception of the difficulty experienced by the FO in learning the procedures associated with the various types missions. If we selected the "Adjust Fire" mission as a reference point in measuring the difficulty of learning the procedures associated with this type mission, how would other type missions compare with the "Adjust Fire" mission in terms of difficulty of learning the procedures

A. The registration procedure is
___ easier to learn than the Adjust Fire mission
___ about the same degree of difficulty as the Adjust Fire mission
___ slightly more difficult to learn than the Adjust Fire mission

B. The illumination mission procedure is
- ___ easier to learn than the Adjust Fire Mission
- ___ about the same degree of difficulty as the Adjust Fire mission
- ___ slightly more difficult to learn than the Adjust Fire mission
- ___ materially more difficult than the Adjust Fire Mission
- ___ one of the most difficult of all firing missions

C. The Coordinated Illumination/HE mission procedures are
- ___ earier to learn than the Adjust Fire mission
- ___ about the same degree of difficulty as the Adjust Fire mission
- ___ slightly more difficult to learn than the Adjust Fire mission
- ___ materially more difficult than the Adjust Fire mission
- ___ one of the most difficult of all firing missions

D. The Smoke HC mission procedures is
- ___ easier to learn than the Adjust Fire mission
- ___ about the same degree of difficult as the Adjust Fire mission
- ___ slightly more difficult to learn than the Adjust Fire mission
- ___ materially more difficult than the Adjust Fire mission
- ___ one of the most difficult of all firing missions

E. The "Fire for Effect" (no adjustment) mission procedure is
- ___ easier to learn than the Adjust Fire mission
- ___ about the same degree of difficulty as the Adjust Fire mission
- ___ slightly more difficult to learn than the Adjust Fire mission
- ___ materially more difficult than the Adjust Fire mission
- ___ one of the most difficult of all firing missions

The following questions pertain to the mortar FDC.

90. The following is one 4 step approach toward training an FDC.

Step 1 is essentially individual MOS skill training.

Step 2 is team practice where individuals become accustomed to performing their assignments <u>accurately</u> and in working with other members of the FDC team.

Step 3 is team drill where individuals become accustomed to performing <u>accurately</u> and in a <u>timely</u> manner in conjunction with other members of the FDC team.

Step 4 is essentially a team drill set in a field environment.

The FDC team performs accurately and in a timely manner and coordinates with other elements of the section or platoon through live firing .

A. Do you believe this approach is a realistic and effective way to train an FDC? ___ Yes ____ No
Discuss if desired.

B. Does not this training approach imply that a battery FDC can become quite proficient in meeting accuracy and time criteria through steps 1, 2, 3.without live firing?
____ Yes ___ No
Discuss if desired.

C. Does not the training approach imply that a battery FDC requires the live firing primarily to coordinate FDC functions with the FO and the mortar section functions?
____ Yes _____ No
Discuss if desired.

91. Assume that you are the senior member of the Mortar FDC. All other personnel in the FDC are newly arrived from FST. Assume further that you the FDC personnel within the time constraints normally available in the platoon. How many months would you estimate it would require before the FDC was ready to participate in the first live firing exercises? ________ months

92. Referring to question 91, given the number of training months required, what would you expect the proficiency of the FDC to be Prior to participating in the first live firing exercise. Mark X on the appropriate line.

___ 10% Proficiency
___ 20% Proficiency
___ 30% Proficiency
___ 40% Proficiency
___ 50% Proficiency
___ 60% Proficiency
___ 70% Proficiency
___ 80% Proficiency
___ 90% Proficiency
___ 100% Proficiency

93. After the first live firing exercise of 1 to 2 days what would you expect the FDC proficiency to be, based upon the standards stated in Part II? Mark (X) on the appropriate line.

___ 10% Proficiency
___ 20% Proficiency

___ 30% Proficiency
___ 40% Proficiency
___ 50% Proficiency
___ 60% Proficiency
___ 70% Proficiency
___ 80% Proficiency
___ 90% Proficiency
___ 100% Proficiency

94. Referring to question 93, in evaluating the benefits of a live firing exercise to the new members of the FDC, what do you see as the principal benefits? Mark in order of importance (1, 2, 3, 4). Mark 0 if not applicable.

___ validation of acquired skills demonstrated by live fire.
___ FDC confidence in their ability to perform (morale)
___ learning mission procedures
___ coordination among members of the FDC
___ coordination among the FDC and the FO and the mortars
___ refining accuracy and timing (proficiency) in a field environment

95. Let us assume that the new FDC completed the first live firing exercise. The FDC is subsequently expösted to team practice and team drill within the normal number of hours available for training. The platoon conducts live firing exercises at the frequency indicated in your response to question 5. How would you expect the FDC proficiency would increase. Mark an X on the appropriate line for each of the 2nd through the 8th live firing exercises.

Proficiency (%)	Firing Exercise #2	#3	#4	#5	#6	#7	#8
10	___	___	___	___	___	___	___
20	___	___	___	___	___	___	___
30	___	___	___	___	___	___	___
40	___	___	___	___	___	___	___
50	___	___	___	___	___	___	___
60	___	___	___	___	___	___	___
70	___	___	___	___	___	___	___
80	___	___	___	___	___	___	___
90	___	___	___	___	___	___	___
100	___	___	___	___	___	___	___

96. Referring to questions 93 and 95, assume there was **no** live firing. Training Devices are substituted for the normally scheduled live field firing exercise. Team drill and team practice are conducted at the normal rate. please indicate how the FDC proficiency would increase over an 8 month period.

Proficiency (%)	Months 1	2	3	4	5	6	7	8
10	___	___	___	___	___	___	___	___
20	___	___	___	___	___	___	___	___
30	___	___	___	___	___	___	___	___
40	___	___	___	___	___	___	___	___
50	___	___	___	___	___	___	___	___
60	___	___	___	___	___	___	___	___

70 ___ ___ ___ ___ ___ ___ ___ ___
80 ___ ___ ___ ___ ___ ___ ___ ___
90 ___ ___ ___ ___ ___ ___ ___ ___
100 ___ ___ ___ ___ ___ ___ ___ ___

97. Let us assume that the FDC has been training and participating in live firing at the rate indicated in your answer to question 5 and that the FDC has achieved an 80% proficiency. For reasons beyond the control of your unit, no live firing exercises is possible for a period of 3 months. At the end of 3 months with no personnel turnover, you participate again in a live firing exercise.

How much of a decline (if any) in the proficiency of the FDC would you expect to experience. Proficiency would decrease from 80% to

___ 75-79%
___ 70-74%
___ 65-69%
___ 60-64%
___ below 60%
___ proficiency would not decrease at all

98. In reference to question 97, would the decrease in proficiency be due to:
Mark 1, 2, 3, 4 in order of importance. Mark 0 if not a problem.

___ section personnel not working together as a team effort in the required time
___ some section personnel individually slow in applying currint procedures
___ some section personnel individually making errors in procedure
___ some section personnel forgetting the correct procedures

99. Given the proficiency decrease stated in your response to question 97, how many additional live firing exercises if any at the rate specified in your answer to question 5 do you think would be required before the FDC again achieved an 80% proficiency?

___ 1 more live firing exercise
___ 2 more live firing exercise
___ 3 more live firing exercise
___ 4 more live firing exercise
___ 5 or more additional live firing exercises

100. Referring to question 99, if the FDC fired twice as frequently as your answer to question 5, how many live firing exercises would be required to again achieve an 80% proficiency? Check the appropriate block.

___ none, live firing not required
___ 1 more live firing exercise
___ 2 more live firing exercises
___ 3 more live firing exercises
___ 4 more live firing exercises
___ 5 more live firing exercises
___ 6 more live firing exercises
___ 7 more live firing exercises
___ 8 more live firing exercises

101. When FDC personnel are transferred from the mortar platoon are their replacements trained or untrained?

___ % trained
___ % untrained

102. If the FDC trained at the frequency described in question 5 and the FDC was 90% proficient, do you feel that the replacement of one (1) of the FDC personnel in a 3 month period would cause a material drop in section proficiency?
___ No _____ Yes, proficiency would decrease from 90% to _____%.

103. In reference to question 102, do you feel that, the replacement of 2 FDC personnel in a three month period would cause a material drop in section proficiency?
___No _____Yes, proficiency would decrease from 90% to ____%.

104. If the FDC normally participates in 2 days of live firing at least once per month, and experiences a turnover of personnel which reduces the FDC proficiency from 90%-70%

A. How many months at this training rate would be required before the FDC could regain the 90% level of proficiency?
_______Months

B. If the frequency of live firing were increased to 3 days of live firing per month, how many months would be required before the FDC could regain the 90% level of proficiency?
______Months

C. If the FDC were required to regain 90% section proficiency within 45 days after the turnover of personnel, how many live firing days do you think the FDC would need?
______days

D. Do you feel that FDC proficiency of 90% could be regained without live firing? Yes ______ No______

E. If the FDC proficiency dropped from 90% to 70% because of personnel turnover, how much of an improvement in proficiency could be anticipated without live firing?

___ Proficiency of 90% could be regained without live firing
___ Proficiency of 85% could be regained without live firing
___ Proficiency of 80% could be regained without live firing
___ Proficiency of 75% could be regained without live firing
___ Proficiency of less than 75% could be regained without live firing

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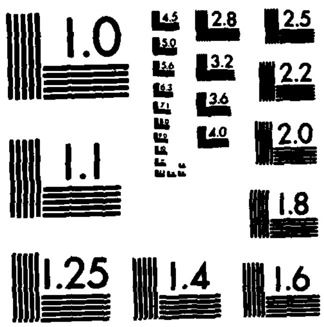

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Artillery Questionnaire

Part I General Instructions
Part II Standards of Proficiency
Part III Questionnaires
- A Command and Staff
- B Battery XO, Battery Gunnery Sergeant, Platoon Sergeant
- C Forward Observer
- D Fire Direction Officer
- E Howitzer Section Chief

Personal Data

1. Name ______________________________

2. Rank ______________________________

3. What is your current position? ______________________________

4. How many years have you been in the USMC? ______________________________

5. What experience have you had in artillery gunnery? Please describe jobs you have had conducting or supervising tank gunnery training to include how long you served in the job and briefly what the job entailed.

6. Briefly list your military assignments below:

Date From	Date To	Position	Unit/Location	Brief Job Description

Part I <u>General Instructions</u>

The Marine Corps Development and Education Command has commissioned a study of training ammunition requirements for crew served weapons including artillery and mortars. This questionnaire deals with artillery. You have been selected to respond to this questionnaire because of your recognized knowledge of training and performance in artillery weapons. The purpose of the questionaire is to obtain your judgement on such issues as the contribution of live firing to section and battery proficiency, the contribution of simulators and training devices to section and battery proficiency, the frequency at which training should be conducted and the effects of personnel turnover and crew skill degradation on section and battery proficiency.

Five (5) sets of questionnaires have been prepared. These include 1) the Command and Staff questionnaire which is appropriate for the Artillery Battalion Commander, Artillery Battalion S-3 and the Artillery Battery Commander; 2) the questionnaire for the Battery Executive Officer, Battery Gunnery Sergeant and Platoon Sergeant; 3) the Battery Forward Observer; 4) the Battery Fire Direction Officer and 5) the Howitzer Section Chief. Each of the five (5) sets of questionnaires has been prepared for a limited number of personnel in each category. Therefore your responses to the questions will have a significant impact on the results of the study.

Please read each question carefully and thoroughly consider your response. The nature of the subject material in this study is abstract. There are limited sources of "hard" verifiable data for this type of study. Your individual bank of experience is the best source of information and you have been selected for this questionnaire based on your experience and knowledge.

Many of the questions are complex and call for judgments to be made. A major theme of the questionnaire deals with the relationship of the "live firing" of ammunition to "proficiency" or the ability of a section or battery to perform in an accurate and responsive manner. Section Chiefs and Unit Commanders tend to have different standards of proficiency and to define proficiency in differing terms. For the purposes of uniformity we define "proficiency" in terms of accuracy and time. For any given mission, there are accuracy and time criteria or standards for each section (FO, FDC, Howitzer Sections) and for the Battery as a whole.

These standards or criteria are taken from the MCCRES standards and are presented in Part II for each type section and for the Battery. <u>Please review these standards carefully.</u>

For purposes of this questionnaire, if the section or battery performs to the accuracy and time standards established for a given type of mission, that section or battery is 100% proficient. It passed the test and satisfied the criteria. If the section or battery did not perform to both the accuracy and time standards established for a given type of mission, that section or battery failed and thus its proficiency in that mission is zero per cent proficiency.

The questionnaire addresses many subjects in terms of a per cent of proficiency. For purposes of this questionnaire, a section or battery which is 80% proficient is one which performs its required functions within the accuracy and time criteria in 80% of the total missions fired. During a series of normal live firing exercises, it is anticipated that the section or battery will fire a wide variety of missions (Adjust Fire, Registrations of various types, Illumination, Coordinated Illumination and High Explosive missions, Smoke, ICM/FASCAM and Fire For Effect missions).

Each type mission may have criteria for each section of the battery and for the battery as a unit. These are presented in Part II as previously noted. It is further assumed that in the course of a series of normal live firing exercises that certain types of missions such as "Adjust Fire" missions will be fired more frequently than other types such as "Smoke"; and that registrations will be fired more frequently than coordinated. Illumination/HE missions.

If a battery live firing exercise consisted of 1 Precision Registration, 6 Adjust Fire missions, 1 Illumination mission and 2 Fire for Effect missions (a total of 10 missions), the battery proficiency and section proficiency would be measured by their ability to perform to the accuracy and time criteria for each type mission. If the battery or section met the standards for both accuracy and time in the Registration mission, in 5 of the 6 Adjust Fire missions and in the 2 Fire for Effect missions and failed to meet the standard in 1 of the Adjust Fire missions and the 1 Illumination mission, the battery or section satisfied the criteria in 8 of the 10 missions fired. Therefore its proficiency for that live firing exercise would be 80%.

Other questions in the latter portion of the questionnaire address the attainment and maintenance of proficiency in a specific type of mission.

Again, please consider the questions and your response carefully. Your cooperation and the information provided is sincerely appreciated.

Part II
Standards of Proficiency

Source: Marine Corps Combat Readiness Evaluation System (MCCRES)

Howitzer Section

- Projectiles with PD fuzes prepared for firing in 30 seconds or less and set with PD or delay function as announced.

- Projectile with Fuze VT or Time prepared in 40 seconds or less and time set to 0 second accuracy for Fuze VT and to the nearest 0.1 second for accuracy for Fuze Time.

- Propellant cut to the announced charge.

- Howitzer ready to fire within ______ seconds after receipt of "Quadrant Elevation" for initial round.

105mm	30 seconds
155mm Towed	45 seconds
155mm SP	60 seconds

- Howitzer ready to fire within ______ seconds after receipt of "Quadrant Elevation" for subsequent rounds.

105mm	30 seconds
155 mm Towed	35 seconds
155mm SP	60 seconds

- Quadrant Elevation and panoramic telescope mount bubbles are centered prior to firing.

- Correct alignment of panoramic telescope on collimater/aiming posts is obtained prior to firing.

- Correct deflection and QE settings are used.

- When FDC directs firing on a pre planned priority target, howitzer must be prepared to fire within 30 seconds.

Fire Direction Center

- In an adjust fire mission
  - Initial round data is computed within 45 seconds after the FDC receives target location.

  - Subsequent round data is computed within 25 seconds after the FDC receives the subsequent corrections.

  - QE and Deflection Data computed to within 3 mil accuracy.

  - Fuze settings determined to the nearest 0.1 second.

- In an illumination mission

  - Initial round data computed within 60 seconds after the FDC receives target location.

  - Subsequent round data is computed within 15 seconds after FDC receives subsequent corrections.

- In a smoke mission

  - Firing data is computed within 30 seconds after FDC receives the target location.

  - Appropriate smoke fuze correction is applied.

- In a precision registration mission

  - Obtain correct adjusted data

  - Check round fired from base piece impacts within 50 meters of a surveyed target within transfer limits

  - Determine GFT setting and deflection corrections within 2 minutes after completion or registration.

  - Compute and apply FADAC residuals within 3 minutes after completion of registration.

- In a high burst registration with 2 surveyed observation posts

  - Check round fired from base piece impacts within 50 meters of a surveyed target within transfer limits.

  - Upon completion of registration, correction is determined and applied within
    3 minutes using FADAC
    5 minutes - manual computation

- Preparation of Survey Firing Chart

  - 4 minutes after FDC receives survey data, FDC plots battery center, primary deflection index, radar location and primary azimuth index.

Forward Observer

- Must determine target location within 30 seconds of identifying target. Target location must be within 300 meters of actual target location.

- Must determine target location within 50 seconds of identifying target. Target location must be determined to following accuracies:

coordinates	200 meters
OT Direction	10 mils
lateral Shift	10 meters

distance 100 meters

- Must transmit a complete call for fire within 60 seconds of target identification. Target location must be within 200 meters of actual location. Appropriate shell/fuze combination is requested. Correct call for fire and communications procedures are used.

- Must conduct an adjust fire, fire for effect and illumination missions on targets of opportunity after target identification, observer must transmit complete call for fire within 60 seconds, and send subsequent corrections within 15 seconds of HE sound burst. No more than 3 adjusting rounds used in the adjust fire mission. Target location must be within 200 meters of actual target location. Fire For Effect must be within 50 meters of target. Illumination is adjusted to provide maximum illumination on target.

- Must conduct a smoke mission, transmiting a complete call for fire within 2.5 minutes, and transmit subsequent HE corrections within 25 seconds of sound burst. Target location must be within 200 meters of actual location. Smoke must provide adequate coverage of target.

Battery Performance

Requirement		
1. Conduct High Angle Will Adjust Mission	105mm 10 minutes 155mm 11 minutes	Fire for Effect 100 meter radius of target
2. Conduct 2 simultaneous adjust fire missions from separate observers. Second mission request is received within 60 seconds of first mission	105mm 8 minutes 155 towed 8 minutes 155 SP 9 minutes Time from observer identifying first target to last round fired for effect on last target.	same
3. Conduct Illumination Mission	7 minutes	Target adequately illuminated.
4. Conduct Illumination Mission and an HE mission under Illumination	7 minutes for illumination 11 minutes for HE	Target adequately illuminated. FFE 100 meters radius of target
5. Conduct Smoke Mission	3 minutes (first rounds fired in 1 1/2 minutes)	Target obscured
6. Deliver Suppressive fires on planned target	1 minute for 105mm (bt rounds in 30 seconds) 2 1/2 minutes for 155T & SP	75% of rounds within 200 meters radius circle
7. Conduct Fire for Effect mission on target of opportunity that is within transfer limits of registration data. Shell HE	105mm - 1 minute 155 Towed - 1 minute SP - 2 minutes	100 meters radius of Tgt.
8. Conduct aerial observer "Will Adjust" mission	From AO identification of target to last round in FFE 105mm - 7 minutes 155 Towed - 7 1/2 minutes SP - 8 1/2 minutes	100 meter radius of Tgt.
9. Conduct Fire for Effect mission on target using ICM	2 1/2 minutes from observer identification to last round in FFE	FFE pattern covers target
10. Deliver Immediate suppressive fire on target of opportunity without adjustment	3 minutes from observer identification of target to last round. First round fired in 1 minute and 20 seconds.	75% of rounds within 200 meter radius circle

Questionnaire A

Questionnaire for Command and Staff
(Battalion Commander, Battery Commander, Battalion S-3) Section I

1. Please indicate the type of artillery unit (105mm How, 155mm Towed, 155mm SP and 203mm) and the number of months you have served in any of the 3 billets noted above.

Type Unit	Number of Months	Billet

2. Are you currently serving in any of the billets noted above?
   Yes__No__. If yes, which billet ____________________.

3. How long has it been since you served in the last of the billets noted above?
   _____ months

You will find that a great number of questions in this questionnaire deal with the subject of "proficiency". You will be asked to make judgements concerning "proficiency" of the battery based on exposure to training including live fire training. In order to assist you, the term "proficiency" is based upon 2 elements, the ability to perform accurately and the ability to perform in a timely manner. Both elements must be present to be "proficient". The criteria for both accuracy and time in any type of mission is extracted from the MCCRES standards for proficiency. For purposes of this questionnaire, a Battery which is 80% proficient is one which is capable of performing the required tasks within the accuracy and time criteria in 80% of the total missions fired. If a Battery fired 20 missions of a various mix of Adjust Fire, Registration , Smoke, Illumination, ICM etc. and satisfied the accuracy and time criteria in 16 of those missions, that Battery would be considered 80% proficient. If it satisfied the criteria in 18 of those 20 missions, it would be considered 90% proficient.

Please review the portions of Section II that relate to the Battery Proficiency with respect to the MCCRES criteria for proficiency in various types of missions.

4. A. Do you believe the MCCRES standards are attainable and realistic?
   Yes__No__

   B. If your unit were tested within one week, how do you think it would be evaluated in terms of proficiency?

   91-100% ___
   81-90% ___
   71-80% ___
   61-70% ___
   51-60% ___
   beloe 50% ___

   C. Would your unit proficiency be representative of similar units in the regiment?
   Yes ___
   No, my unit would probably be evaluated __% higher than the average unit.

No, my unit would probably be evaluated ___% lower than the average unit.

5. Based on your experience, please address the following questions.

   A. Estimate the average number of days per quarter that your battery participates in live firing.____ days per 3 month period

   B. Estimate the number of live rounds expended by the battery on the average live firing day. ____ # rounds per firing day

   C. Do you feel that your unit(s) fire more frequently or expends more live ammunition per shoot than other batteries of the regiment. Check (1) (2) or (3) and check question subsection if applicable.

   ( ) No, my battery trains with live firing at about the same frequency and expenditure as other units in the regiment.

   ( ) Yes my battery trains more frequently with live firing than the average battery. Check one:

   ( ) a) 10% more frequently
   ( ) b) 20% more frequently
   ( ) c) 30% more frequently
   ( ) d) 40 % more frequently
   ( ) e) greater than 40% more frequently

   ( ) No my battery trains with live firing less frequently than the average battery. Check one:

   ( ) a) 10% less frequently
   ( ) b) 20% less frequently
   ( ) c) 30% less frequently
   ( ) d) 40% less frequently
   ( ) e) greater than 40% less frequently

6. Since the unit commander is the officer primarily responsible for the training status of your unit(s), how do you approach the problem of deciding how many live rounds of artillery ammunition you need on an annual basis? Please discuss in detail.

7. In order of importance, what factors directly influence your training plan for overall unit proficiency. Check 1 for most important, 2 for second in importance, 3, 4, etc. Mark 0 if not applicable.

___ Availability of time for training
___ Availability of adequate ranges
___ Turnover of personnel
___ Availability of adequate training devices
___ Availability of quantities of live fire ammunition

8. If the annual training allowance for a certain type artillery unit is X rounds per weapon, it means that that type artillery unit cannot request more than the stated allowance for annual live fire training.

   A. Do you relate the quantity shown in the annual allowance with a "proficiency" in performance? Yes__No__

   B. Do you have any opinion as to how the allowance was derived?
   No__
   Yes,__, I believe the allowance was derived from (please explain)

9. Training in many types of weapons does not consume the quantities of ammunition which are authorized in the annual training allowance. Artillery training consumption of live ammunition correlates at a level closely approaching the annual allowance. Check ( ) the most appropriate in order of importance.

   Do you think this is because
   ___ training devices available to artillery are inadequate
   ___ concern that failure to fire the annual allowance will result in a reduction of the annual allowance
   ___ live firing in the quantities used is absolutely essential to the training of the artillery unit
   ___ live firing in the quantities used is the best way to validate the training status of the Battery and is good for troop morale

Skill Learning and Degradation
It is recognized that many factors may tend to degrade the proficiency of a unit. Two of the major factors are skill degradation and personnel turnover. The following questions relate to the training situation where ther is no turnover of personnel for a period of 6 months.

10. Assume you take command of a new unit with experienced unit commanders and section chiefs but with the majority of personnel newly reported from FST.

   A. How many months would you estimate it would require before the battery was prepared to participate in the first live fire exercise?___months

   B. Which section(s) of the battery would require the greatest time to train?
   ___ FOs
   ___ FDC
   ___ Howitzer sections

   C. Reviewing the proficiency standards of MCCRES in relation to accuracy and time, could you evaluate the unit before live firing as to their expected proficiency?

   ___ Yes, I would expect a battery proficiency level of ___%
   ___ No, I would have to see the live firing to evalute the battery performance

   D. Referring to question 10C, could you evaluate any section(s) of the battery prior to live firing?

___ No
___ Yes, the FO only
___ Yes, the FO and FDC only
___ Yes the FDC only
___ Yes, the FDC and the howitzer sections only
___ Yes, the howitzer sections only
___ Yes, the FO and the howitzer sections only
___ Yes, all sections

Please explain your answer briefly.

11. Continuing with the assumption of question 10, further assume that the battery participated in a 1 to 2 day live firing exercise. Approximately what level of proficiency would you expect to see for the battery as a whole and for the FO, FDC and Howitzer sections. Please mark an X on the appropriate line.

Proficiency Level	Battery as a whole	FO Section	FDC Section	Howitzer Section
100%	___	___	___	___
90%	___	___	___	___
80%	___	___	___	___
70%	___	___	___	___
60%	___	___	___	___
50%	___	___	___	___
40%	___	___	___	___
30%	___	___	___	___
20%	___	___	___	___
10%	___	___	___	___

12. Continuing with question 11, please provide your best estimate of how the proficiency levels discussed in question 11 would change:

A. After the unit had participated in 3 additional live firing exercises at the frequency of firing and the round expenditure indicated in question 5.

Proficiency Level	Battery as a whole	FO Section	FDC Section	Howitzer Section
100%	___	___	___	___
90%	___	___	___	___
80%	___	___	___	___
70%	___	___	___	___
60%	___	___	___	___
50%	___	___	___	___
below 50%	___	___	___	___

B. After 3 more additional live firing exercises under the same conditions as question 10?

Proficiency Level	Battery as a whole	FO Section	FDC Section	Howitzer Section
100%	___	___	___	___
90%	___	___	___	___
80%	___	___	___	___
70%	___	___	___	___
60%	___	___	___	___
50%	___	___	___	___
below 50%	___	___	___	___

C. If 6 batteries of "all new" crews were randomly selected for evaluation after 3 live firings and after 6 live firings, would you expect the average proficiency levels would agree with those stated in question 12A and 12B?

___Yes
___No, the average section would be
  ___10% more efficient
  ___20% more efficient
  ___30% more efficient
___No, the average section would be
  ___10% less efficient
  ___20% less efficient
  ___30% less efficient

D. If 6 batteries of "all new" crews were randomly selected under the conditions of questions 12A, B & C, the best battery would be ___% more proficient than the average section and the worst battery would be ___% less proficient than the average battery.

13. Refering to question 12, if the frequency of live firing or if the quantity of ammunition expended were increased 50% during the same time frame, would you expect a material improvement in proficiency over what was indicated in your response to question 12.

No___
Yes___, I would judge that battery overall proficienty might increase at a rate ___% faster

14. If the frequency or quantity of live firing increased as suggested in question 13, which sections of the battery would benefit the most?

___ FO
___ FDC
___ Howitzer sections
___ all would benefit equally

Please explain your answer.

15. Assume that you were to take command of an artillery battery which was composed of typical marines who had been participating in classroom instruction, section training, and had been participating in live firing exercises to the degree you indicated in question 5. After observing the battery for a 30 day period in which there was no live firing, could you evaluate the battery in terms of probable proficiency?

__No
__Yes, the entire battery
__Yes, the FO only
__Yes, the FO and FDC only
__Yes, the FO and howitzer sections only
__Yes, the FDC only
__Yes, the FDC and howitzer sections only
__Yes, the howitzer sections only

Please explain your answer.

16. Refering to question 15, if you had the opportunity to observe the battery in a field environment in the conduct of a CPX during the 30 day observation period, could you evaluate the battery in terms of probable proficiency?

__No
__Yes, the entire battery
__Yes, the FO only
__Yes, the FO and FDC only
__Yes, the FO and howitzer sections only
__Yes, the FDC only
__Yes, the FDC and howitzer sections only
__Yes, the howitzer sections only

Please discuss your answer.

17. Based upon your experience, how do you believe that training with live firing effects the battery proficiency or the proficiency of the sections within the battery?

A. Live Firing effects the proficiency of the battery

__ not at all
__ no, it simply validates the proficiency achieved in non firing training. It demonstrates what we are already capable of doing
__ no, live firing adds realism to training. It is more exciting but does not effect proficiency

___ yes, live firing directly effects proficiency in a material way
___ yes, but only in coordinating FO-FDC-Howitzer section activities in real time and accuracy.

B. Live firing effects the proficiency of the Forward Observer

___ not at all
___ no, it validates his capability to perform
___ yes, the observer proficiency increases materially as a result of live firing

C. Live Firing effects the proficiency of the FDC

___ not at all, since the FDC does not see either the target or the projectile being fired
___ no, the FDC needs live firing only to obtain registration corrections
___ no, live firing only validates the product of the FDC effort, it does not contribute to the effort
___ yes, the FDC proficiency is materially effected by live firing
___ yes, but only in coordinating FO-FDC-Howitzer activities in real time and accuracy

D. Live Firing effects the proficiency of the Howitzer sections

___ not at all
___ no, it simply validates what the howitzer sections are already capable of doing
___ no, live firing adds to the realism
___ yes, live firing adds to proficiency in a material way
___ yes, but only in coordinating FO-FDC and howitzer activities in real time and accuracy.

18. The consumption of live ammunition increases considerably when the battery fires more than a "Battery one" in "fire for effect". Do you feel the proficiency of the battery or the proficiency of the sections benefit from firing a "Battery 2, 3 or 4 rounds in effect?

___ No
___ Yes, it benefits the entire battery
___ Yes, it benefits
 ___ FO
 ___ FDC
 ___ Howitzer sections

If yes, please explain your answer.

19. How frequently does your unit fire more than a "battery one" in the fire for effect phase of an "Adjust Fire" mission?

___ never
___ once in about twenty missions
___ once in about ten missions

___ once in about five missions
___ every other mission
___ every mission

20. Referring to question 19, do you believe your response to question 19 is representative of the batteries in the regiment?

___Yes
___No, the average battery fires a "battery one" ___% more frequently
___No, the average battery fires a "battery one" ___% less frequently

21. Let us assume that your battery(s) had been training and participating in live firing at the rate indicated in question 5 and achieved a proficiency level of 80%. For reasons beyond your control, no live firing is possible for a period of 3 months. At the end of 3 months with no personnel turnover, your battery again participates in a live firing exercise.

A. How much decline in the proficiency of the battery would you expect to experience. Proficiency would decrease from 80% to

___ 75-79%
___ 70-74%
___ 65-69%
___ 60-64%
___ below 60%

B. In which section of the battery would the loss in proficiency probably be the greatest?

___ FO
___ FDC
___ Howitzer Sections

22. Continuing with question 21, in a random selection of 5 batteries within the regiment, all of which were initially 80% proficient, and live firing were suspended for 3 months and then resumed, what would you expect the distribution to be?

___ batteries would drop proficiency to 75-79%
___ batteries would drop proficiency to 70-74%
___ batteries would drop proficiency to 65-69%
___ batteries would drop proficiency to 60-64%
___ batteries would drop proficiency to below 60%

23. Referring to questions 21 and 22, the principal cause for the drop in Battery proficiency would be (mark in 1,2,3,4,5 order of importance):

___ sections not working together as a battery team
___ section personnel not working together within their sections
___ section personnel making errors
___ section personnel slow in applying procedures
___ section personnel forgetting correct procedures

24. Given the battery proficiency decrease stated in your response to question 21A, how many live firing exercises at the rate specified in your answer to question 5 would be

required before your battery again achieved an 80% proficiency?

___ none, firing not required
___ 1 more live firing exercise
___ 2 more live firing exercises
___ 3 more live firing exercises
___ 4 more live firing exercises
___ 5 more live firing exercises
___ 6 or more

25. If the battery fired twice as frequently as your answer to question 5, how many live firing exercises would be required to achieve a 80% proficiency?

___ none, firing not required
___ 1 more live firing exercise
___ 2 more live firing exercises
___ 3 more live firing exercises
___ 4 more live firing exercises
___ 5 more live firing exercises
___ 6 more live firing exercises
___ 7 more live firing exercises
___ 8 more live firing exercises
___ more than 9

26. Refering to question 21A, suppose after 3 months of no live fire training, subsequent live firing was indefinitely limited to a frequency of only 50% of that indicated in your response to question 5. Under those conditions,

A. What is the highest proficiency level you could expect the battery to attain?
___% proficiency?

B. How many months would it take to attain the above proficiency level?
___ estimated number of months

C. What is the highest level of proficiency that the battery could be expected to maintain?
___%

The following questions deal with the subject of personnel turnover and its effect on the proficiency of your unit. In defining "personnel turnover", let us assume that personnel who "turnover" are those battery personnel who are transferred or reassigned to another command or battery, who are sent TAD for extended periods of time or who are terminated from the service. For purposes of this questionnaire, the "personnel turnover rate" is the number of personnel who leave the battery each month divided by the average number of personnel in the battery. Example: 12 personnel leave the battery during the month. The personnel turnover rate is 12/120 or 10%.

27. Based on your experience,

A. What has the average personnel turnover rate been in your battery over the last six months?

___ Under 5%
___ 5 to 10%

___ 11 to 15%
___ 16 to 20%
___ 21 to 25%
___ 26 to 30%
___ over 30%

B. Is this rate representative of the similar units in the Regiment?

___ yes
___ no, the average may be ___% higher than question 27A
___ no, the average may be ___% lower than question 27A

C. What has been the highest turnover rate that you have ever experienced in a battery?

___ under 10%
___ 11-20%
___ 21-30%
___ 31-40%
___ over 40%

D. When your unit replaces enlisted personnel, what percent of the replacements normally come from FST and what percent come from non-FST?

___ % FST
___ % non FST

28. Based upon your responses to questions 27A, 27C, and 27D, assuming your unit was 90% proficient, how much of a monthly personnel turnover rate could you accept and still maintain 90% proficiency? ___% turnover per month.

29. Assume your unit is at a 90% level of proficiency and that the personnel turnover rate in the unit over a six (6) month period averaged 15% per month. Assume your unit continues to participate in live firing at the same rate indicated in Question 5.

A. How would you describe the changes, if any, in the unit proficiency level?

I would estimate battery proficiency would change as follows: (Fill in all blanks)

___ % proficient after the 1st month of 15% personnel turnover
___ % proficient after the 2nd month of 15% personnel turnover
___ % proficient after the 3rd month of 15% personnel turnover
___ % proficient after the 4th month of 15% personnel turnover
___ % proficient after the 5th month of 15% personnel turnover
___ % proficient after the 6th months of 15% personnel turnover

B. What changes, if any in the training program, would be benefitical to limit the drop in battery proficiency during this turbulent period?

Mark in order of importance
___ % more frequent live firing
___ % more time using training devices
___ % more time on section drills
___ % greater emphasis on classroom instruction and individual skills

C. If the 15% monthly personnel turnover rate effected all sections of the battery on a pro rata basis, which section would likely show the greatest drop in proficiency?

___ howitzer sections
___ FDC
___ FO
___ all would drop equally

D. If the battery proficiency declined as you indicated in question 29A and the remedial action you suggested in question 29B were implemented, how would you estimate the proficiency level of the battery would change over the 6 month period? (Fill in all blanks).

___ % proficient after the 1st month of 15% personnel turnover
___ % proficient after the 2nd month of 15% personnel turnover
___ % proficient after the 3rd month of 15% personnel turnover
___ % proficient after the 4th month of 15% personnel turnover
___ % proficient after the 5th month of 15% personnel turnover
___ % proficient after the 6th months of 15% personnel turnover

30. Assume your unit is at a 90% level of proficiency and that the personnel turnover rate for a 3 month period is 20% per month. Your unit is limited to live firing exercises at the rate indicated in question 5.

A. How would you judge the change in battery proficiency?

I would judge that the battery proficiency would change as follows:

___ % proficient after the 1st month of 20% personnel turnover
___ % proficient after the 2nd month of 20% personnel turnover
___ % proficient after the 3rd month of 20% personnel turnover

31. Referring to question 30, if at the end of 3 months of 20% personnel turnover per month, the battery resumed a normal turnover rate (question 27A), how long do you think it would take before the battery regained its 90% proficiency level, if live firing exercises were conducted at the frequency indicated in question 5?

___ months

32. Referring to question 31, how many months would it take to regain the 90% proficiency level if the frequency of live firing were increased 50% over the level indicated in your response to question 5.

___ months

33. The proficiency of a given section can be measured by the timing and accuracy criteria from Part II MCCRES relating to that section's ability to perform a certain type of mission. The timing and accuracy criteria for the battery requires not only individual section performance at a high level but also the coordination of these sections in an integrated manner to achieve the desired Battery performance level. In your opinion who are these people who perform the coordination functions between the FO, FDC and firing battery?

34. Referring to question 33 can this coordination function be exercised without live firing exercises?

__Yes because______________
__No because______________

35. Do you believe it is possible to have an FO section, an FDC section and Howitzer sections, all of which are 90% proficient, and yet have a battery proficiency that is well below 90% because the sections do not coordinate well with each other?

Yes __
No __

36. If your answer to question 35 was yes, how would you correct this situation. Explain in your own words please.

37. If proficiency is measured in terms of accuracy and time, what are your suggestions regarding how the battery commander and/or battery executive officer might measure the activity of his battery to coordinate the activities of the FO section, FDC and the firing sections without live firing. Please explain in your own words.

38. Refering to question 37, do you think that a sophisticated training device could be constructed which would allow battery as well as section performance (proficiency) to be measured?

__ Yes, explain

__ No, explain

The following questions effect the use of training simulations, simulators and training devices and their effect on unit proficiency.

39. Have you had the opportunity to use the following training devices. Check appropriate blocks.

__ M-31 Trainer 14.5mm
__ M423 (8")
__ M455 (153) Nuclear Training Projectile
__ Field Artillery direct fire trainer
__ Time training fuze
__ Training Set, Fire observation
__ Forward Observer Trainer

40. Which of these devices are available for use in your battery

- __ M-31 Trainer 14.5mm
- __ M423 (8")
- __ M455 (153) Nuclear Training Projectile
- __ Field Artillery direct fire trainer
- __ Time training fuze
- __ Training Set, Fire observation
- __ Forward Observer Trainer

41. As a tool for training personnel, what is your evaluation of current training devices?

- __ they are of very little value
- __ they are of some value
- __ they are of considerable value
- __ they are very important in training personnel

42. In an average training month of 22 days, approximately how many training days per section are devoted to the following types of artillery training in the battery

- __ days of live firing training
- __ days of training using training devices
- __ days of training using cannoneers hop only
- __ days of training using none of the above
- __ days of training (Inspections, General Military Subjects, etc.)

43. What is your principal criticism of training devices if any. Mark ____ in order of importance, 1 most important, 2 next important, etc.

- __ no criticism
- __ they are not designed to effectively improve individual or section performance
- __ they do not adequately measure the accuracy of individual or section performance
- __ they do not adequately measure the time aspect of section performance
- __ they do not adequately simulate the conditions of live firing
- __ they are basically boring to use
- __ they do not present a challenge to the section member to learn

44. Let us assume that your battery is not very proficient (50%) because of a heavy turnover of personnel. <u>In 6 months</u> your battery will be evaluated using the MCCRES standards. There be <u>no</u> live firing exercises until the MCCRES is administered. You may use any type of non live firing training, simulator, devices etc. How would you estimate the battery would perform in live firing at the MCCRES evaluation.

- 91-100% __
- 81-90% __
- 71-80% __
- 61-70% __
- 51-60% __
- below 50% __

What devices or simulations would you use to attain that level. Explain:

45. Refering to question 44, suppose the MCCRES evaluatin were to be given in 3 months instead of 6 months. With no live firing prior to MCCRES, how would you estimate the battery would perform in the MCCRES evaluation?

91-100% ___
81-90% ___
71-80% ___
61-70% ___
51-60% ___
below 50% ___

46. Do you feel that the answers to questions 44 and 45 would be different if you had more capable training devices? ___Yes ___No

47. What specifically do you desire to see in a training device that helps train your battery or sections of the battery. Explain:

48. Let us assume that the frequency of firing and the number of rounds fired in question 5 resulted in a certain high level of proficiency measured in accordance with MCCRES standards.

A. If the live firing frequency were decreased by 1/2 on an annual basis and training devices were substituted, what effect would this have on battery proficiency? Check one.

___ proficiency would remain about the same
___ proficiency would increase 10 to 20%
___ proficiency would increase more than 20%
___ proficiency would decrease 10 to 20%
___ proficiency would decrease more than 20%

B. If the live firing frequency remained the same but the number of live rounds used in each exercise were decreased by 1/2 on an annual basis, and training devices were substituted, what effect would this have on battery proficiency? Check one.

___ proficiency would remain about the same
___ proficiency would increase 10 to 20%
___ proficiency would increase more than 20%
___ proficiency would decrease 10 to 20%
___ proficiency would decrease more than 20%

49. Can you suggest an approach that would increase proficiency and/or maintain proficiency at a high level with a reduction in the use of live ammunition? Explain:

50. How much of a reduction in live ammunition can be achieved using the approach you suggested in question 49? ___%

51. Have you ever taken the MCCRES evaluation? ___Yes___No

52. How well did your unit do? ___passed ___failed

Command and Staff Questionnaire
Section II

Instructions:

There are many types of Artillery fire missions. Many of the missions have some elements common to other type missions (such as adjustment procedures when required). However, each mission has procedures in the Forward Observer, or FDC or Howitzer sections which are unique to each type mission. Please consider the following categories and types of missions.

Category 1 - Registrations

Types

Precision Registration - Low Angle
Precision Registration - High Angle
Mean Point of Impact Registration
High Burst Registration

Category 2 - Adjust Fire Missions

Types

- o Low Angle
- o High Angle

Category 3 - Illumination Missions

Types

- o Illumination only
- o Coordinted Illumination with High Explosive

Category 4 - Types

- o HC
- o WP

Category 5 - ICM/FASCAM

Types

- o ICM
- o RAAMS
- o ADAM

Category 6 - Chemical

Category 7 - Fire for Effect without adjustment

The following series of questions are directed at various aspects of these categories and types of missions. Please review your response to question 5 in Section I of the questionnaire prior to responding to these questions.

53. Based on your experience, how many artillery live fire missions is a battery likely to fire on an average monthly basis.

    ___ missions

54. On an annual basis, would the number of live fire missions at the battery level be equal to 12 times the answer to question #53?
___Yes
___No

If no, please estimate the total number of live fire missions which a battery is likely to fire over a period of 12 months.

___ missions

55. In reference to your response to question 54, how would you estimate that the total number of live fire missions would be fired by category on an annual basis. (Refer to Instruction Section).

Category	1	Registrations	___
	2	Will Adjust HE Missions	___
	3	Illumination Missions	___
	4	Smoke Mission	___
	5	ICM/FASCAM	___
	6	Chemical	___
	7	Fire for Effect w/o adjustment	___
		Total (agrees with response to question 54)	___

56. Would you estimte the number of live fire registration missions of each type on an annual basis.

Category	1	Registrations	
Type:		Low Angle Precision Registration	___
		High Angle Precision Registration	___
		High Burst Registration	___
		Mean Point of Impact Registration	___
		Total (agrees with total registrations category 1 Question 55	___

Many of the questions in Section I of this questionnaire dealt with changes in overall battery proficiency in firing a composite mix of fire missions in live fire training exercises over a period of time. It is is safe to state that Battery proficiency as a whole partly depends upon the proficiency of the battery sections (FO, FDC, Howitzers) in their respective capabilities to conduct each category and type of mission at whatever frequency that type of mission is normally used in training or combat. And in part Battery proficiency depends upon the capability of these sections to properly coordinate their activities with each other. The following questions relate to these subjects and their relationships with live firing. You may wish to review questins 10-26.

57. The Low Angle "Adjust Fire" mission is a type mission used extensively in training and in combat. In considering only the live firing aspects of Adjust Fire missions,

A. How many Low angle "Adjust Fire" missions must a Fort Sill trained Observer conduct in order to attain a proficiency of 90% in that type mission?

Ans ___missions

B. Given that the Observer attains a 90 per cent proficiency in this type mission, how many times per year must the Observer conduct this type mission in order to maintain a proficiency of 90 per cent.

Ans ___ low angle adjust fire missions per year.

C. How many if any live fire low angle Adjust Fire missions must an FDC conduct in order to attain a 90 per cent proficiency in this type mission?

Ans ___ missions

D. On an annual basis, how many if any, live fire low angle Adjust Fire missions must an FDC conduct in order to maintain a 90 per cent proficiency in this type mission?

Ans ___ missions per year

E. How many live fire low angle Adjust Fire missions must the howitzer sections conduct in order to attain a 90 per cent proficiency in this type mission.

Ans ___

F. On an annual basis, how many live firing low angle Adjust Fire missions must the Howitzer sections conduct in order to maintain a 90 per cent proficiency?

Ans ___ missions per year

G. In view of your response to quetions 57A through F, how many live fire "Adjust Fire" missions must the battery conduct in order to attain and maintain a 90% proficiency in this type mission?

Ans ___ live fire Adjust Fire missions to attain the 90% proficiency and ___ missions per year to maintain this proficiency.

58. Let us assume that the battery is 90% proficient in conducting the low angle "Adjust Fire" mission discussed in Question 57. The following questions address the problem of high angle Adjust Fire missions.

A. How many high angle live fire "Adjust Fire" missions must be conducted to attain a 90% proficiency? (Fill in all blanks.)

___ missions for FO Training
___ missions for FDC Training
___ missions for Howitzer section training
The battery would have to fire a total of ___ live fire high angle missions to attain a battery level proficiency of 90%.

B. How many high angle "Adjust Fire" missions must be conducted to maintain a 90% proficiency level. (Fill in all blanks.)

___ missions per year for FO Training
___ missions per year for FDC Training
___ missions per year for Howitzer Training

The battery would have to fire a total of ___ live fire high angle missions per year to maintain a 90% proficiency in this type mission.

59. Assume that the battery and all sections are 90% proficient in conducting an "Adjust Fire" type mission. Let us now consider the Low Angle Precision Registration.

A. How many live fire Low Angle Precision Registrations must a Fort Sill trained Forward Observer conduct in order to attain a proficiency of 90 per cent in that type mission?

He must conduct ___ registrations to achieve 90 per cent proficiency in Low Angle Precision Registration.

B. Given that the Forward Observer attains a 90 per cent proficiency, how many times must the Observer conduct this type mission per year in order to maintain this 90 per cent proficiency level?

___ registrations per year

C. In the adjustment phase of the precision registration, the Observer employs normal adjustment techniques and in the Fire for Effect phase, provides only sensings to the FDC. What unique feature of Low Angle Precision Registration does the Observer learn by live firing?

Please discuss.

D. How many live fire low angle precision registration missions must an FDC and a howitzer section experience to achieve a 90 per cent proficiency?

FDC ___ missions
Howitzer Section ___ missions

E. On an annual basis, how many live fire low angle precision registration missions must an FDC and a howitzer section experience to maintain 90 per cent proficiency in that type mission?

FDC ___ missions per year
Howitzer Section ___ missions per year

F. In view of your response to Question 59 A, B, D & E how many live fire low angle precision registrations must the Battery conduct in order to attain and maintain a 90% proficiency in this type mission.

Ans ___ live fire low angle precision registration missions to attain a 90% proficiency and ___ missions per year to maintain this proficiency.

60. In referring to question 59

A. Since the FDC "sees" neither the effects of the firing on the target nor the actions of the firing howitzer, why does the FDC require "live firing" to be proficient in conducting low angle precision registrations?

Please discuss.

B. Is there an action or procedure by the "Base piece" participating in the Low angle precision registration that is significantly different or unique from any other mission requiring the firing of high explosive ammunition with a point detonating fuze or time fuze?

No ___
Yes ___ What is unique?

61. If an Observer, FDC and Howitzer section is 90% proficient in conducting a low angle registration,

A. How many high angle precision registrations must be conducted to attain a 90 per cent proficiency?

___ missions for the Observer
___ missions for the FDC
___ missions for the Howitzer section

B. How many high angle precision registrations must be conducted annually to maintain a 90 per cent proficiency.

___ missions annually for the Observer
___ missions annually for the FDC
___ missions annually for the Howitzer Sections

C. In view of your response to questions 61 A & B, how many high angle precision registrations must be conducted to attain and maintain a 90% proficiency for the Battery?

Ans. The battery must fire ____ high angle precision registrations to attain a 90% proficiency and fire ___ missions annually to maintain that proficiency.

62. Do you see any actions by the observer in the conduct of the High Angle Registration which are substantially different from his actions in the conduct of a low angle registration?

No ___
Yes ___ Please discuss.

63. Other than the unique procedural aspects of drift and site, do you see any action by the FDC in the conduct of a high angle registration which differs substantially from

the FDC actions in a low angle registration?

No __
Yes __ Please discuss.

64. If the answer to questions 62 or 63 is yes, is live firing required to learn these differences?

Yes __
No __

65. Assume the Battery and all sections are 90% proficient in conducting Adjust Fire missions and Precision Registration missions. We are now concerned with High Burst and Mean Point of Impact Registrations.

In the High Burst, and Mean Point of Impact registrations,

A. The Observer is oriented by the FDC and measures and reports azimuths and verticle angles to the FDC. He performs no adjustment. Does the Observer gain any training from this type registration?

No __
Yes __ Please discuss.

If yes, does the observer require live fire to gain this learning?

B. The FDC determines the firing data to conduct the registration. All rounds are fired using the same data.

Do you see any action by the Howitzer crew that is different in this type mission from any other mission involving the use of HE?

Yes __
No __

C. Other than the procedures for orienting the Observer, what training benefit does the FDC derive from the conduct of this type mission?

Please discuss.

Is live firing required to obtain this benefit?
Yes ___
No ___

66. How many live fire high burst (HB) and/or Mean Point of Impact (MPI) registration must be conducted to attain a 90% proficiency for

___ missions for the FO
___ missions for the FDC
___ missions for the Howitzer sections

67. How many live fire HB and/or MPI registrations must be conducted annually to maintain a 90% proficiency for

___ missions per year for the FO
___ missions per year for the FDC
___ missions per year for the Howitzer

68. In view of your response to questions 66 and 67, the Battery must fire the following number of HB and/or MPI registrations to attain and maintain a 90% proficiency in this type mission.

Ans ___ missions to attain a 90% battery proficiency and ___ missions per year to maintain that proficiency.

69. Assume the battery and all sections are 90% proficient in conducting an "Adjust Fire" mission. We are now interested in the conduct of an Illumination Mission and the conduct of a coordinated mission using Illumination and High Explosive rounds.

In considering only the live firing aspects of Illumination missions

A. How many Illumination missions only, and "coordinated Illumination HE missions" are required to attain a 90 per cent proficiency?

1. A Fort Sill Trained Observer requires ____ missions of Illumination only and ___ missions of coordinated illumination.

2. The FDC requires ____ missions of Illumination only and ____ missions of coordinated illumination

3. The howitzer sections require _____ missions of Illumination only and missions of coordinated illumination.

B. Given that the Observer, FDC and Howitzer Sections achieve a 90 per cent proficiency in the conduct of Illumination only and Coordinated HE Illumination, how many times per year must these type missions be conducted to maintain the 90 per cent proficiency?

1. The Observer requires ______ Illumination only missions per year and coordinated illumination missions per year.

2. The FDC requires _______ Illumination only missions per year and coordinated illumination missions per year.

3. The Howitzer Sections require ____ illumination only missions per year and ___ coordinated illumination missions per year.

70. In view of your response to questions 69 A & B, how many illumination only and coordinated illumination/HE missions must the Battery fire to attain and maintain a 90% proficiency in these type missions?

Ans. The battery must fire ____ Illumination missions to attain a 90% proficiency and fire ___ missions per year to maintain that proficiency.

Ans. The battery must fire ___ Coordinted Illumination/HE missions to attain a 90% proficiency and fire ___ missions per year to maintain that proficiency.

71. Is there any practical way to "simulate" a coordinated Illumination/HE mission?

No ___
Yes ___ Please discuss.

72. Assume that the Battery and all sections are 90% proficient in conducting an "Adjust Fire" mission. We are now interested in the conduct of a "Smoke" mission which requires adjustment. In considering only the live firing aspects of Smoke missions,

A. How many Smoke missions are required to achieve a 90 per cent proficiency for:

1. A Fort Sill Trained Observer requires ____ smoke missions to attain 90% proficiency.

2. The FDC requires ___ smoke missions to attain 90% proficiency.

3. The Howitzer sections require ______ smoke missions to attain 90% proficiency.

B. Given that the Observer, FDC, and Howitzer Section attain a 90 per cent proficiency,

1. the Observer requires _____ smoke missions per year to maintain 90% proficiency.

2. the FDC requires ______ smoke missions per year to maintain 90% proficiency.

3. the Howitzer Sections require ____ smoke missions per year to maintain 90% proficiency.

73. In view of your response to questin 72 A & B, how many smoke missions must the Battery fire to attain and maintain a 90% proficiency in this type mission?

Ans. The battery must fire _____ smoke missions to attain a 90% proficiency and fire ___ smoke missions per year to maintain that proficiency.

74. Assume that the Battery and all sections are 90% proficient in conducting an "Adjust Fire" type mission. We are now interested in the conduct of an ICM/FASCAM mission which requires adjustment.

In considering only the live firing aspects of ICM/FASCAM,

A. How many ICM/FASCAM missions are required to attain a 90 per cent proficiency for:

1. a Fort Sill trained observer requires ___ missions
2. the FDC requires ___ missions
3. the Howitzer sections require ___ missions.

B. Given that the Observer, FDC and Howitzer Sections achieve a 90 per cent proficiency in the conduct of ICM/FASCAM missions, how many times per year must these type missions be conducted to maintain the 90 per cent proficiency?

1. the Observer requires ___ missions per year
2. the FDC requires ___ missions per year
3. the Howitzer Sections require ___ missions per year

75. In view of your response to question 74 A & B, how many ICM/FASCAM missions must the Battery fire to attain and maintain a 90% proficiency in this type mission?

Ans. The battery must fire ___ ICM/FASCAM missions to attain a 90% proficiency, and fire ___ ICM/FASCAM missions per year to maintain that proficiency.

76. If an FO is fully qualified to conduct an "Adjust Fire" mission, what unique feature if any is there in the adjustment phase of a Smoke or ICM/FASCAM mission since both adjustments are conducted with an HE round. Please discuss.

77. In considering only the live firing aspects of Fire for Effect missions (no adjustments), does the live firing serve only as a means of validation or does it serve as a training vehicle?

___ validation only
___ training vehicle (please discuss in what manner it "trains" personnel.

78. It is possible to have an Observer, FDC and Howitzer sections each of which have a very high proficiency level, yet on a battery level, the battery performs only moderately well. To what source or sources would you attribute this situation?

a. ___ lack of adequate CPX to improve proficiency on a battery level
b. ___ lack of, or an inadequate unit standard operating procedure (SOP)
c. ___ lack of personnel familiarity with a unit SOP
d. ___ all of the above
e. ___ none of the above

79. How important would you evaluate a battery SOP as a vehicle to improve the proficiency of the battery through the coordination of the various elements of the battery.

a. ___ critically important
b. ___ of significant importance
c. ___ moderately important
d. ___ an aid but not a principal guidance document
e. ___ of minor importance

80. What do you consider the most effective vehicle or approach to improve the proficiency of the battery by coordination among proficient sections. Please discuss.

81. Have the units with which you have served, used battery SOPs?

a. ___ no
b. ___ yes, but the SOPs was marginally adequate
c. ___ yes, but the SOP was not used as a principal guidance document
d. ___ yes, and the SOP was fully adequate and was used as a principal guidance document.

82. It has been observed that a great variety of MOS and non MOS subjects are scheduled and taught to battery level personnel over a 12 month period. However, the unit SOP very rarely if ever appears as a subject on the training schedule. It appears to be a topic with which personnel are expected to become familiar with on their own. Do you find that this is generally the case?

a. ___ yes
b. ___ no, the subject matter of the SOP is routinely scheduled and taught on the battery level
c. ___ no, the subject matter of the SOP is routinely scheduled and taught only on the section level, not on the battery level.

83. Have you ever taken a written test or evaluation of your battery SOP?

Yes ___
No ___

84. With respect to the planning aspects for live firing exercises, it is often remarked that some units train to go to the field while other units merely train in the field. The implication is that the unit which prepares well for field training tends to validate its proficiency by live firing, and conversely, the unit which makes

inadequate preparations for field training, compensates for that inadequacy by using live fire training as a learning vehicle rather than a validation vehicle. Would you agree with this statement? Select one answer.

Yes ___
Yes, but ___ (please discuss)

No ___ (please discuss)

No, but ___ (please discuss)

85. With respect to live firing, Artillery battery proficiency is measured in terms of accuracy and time criteria. Each section within the battery also has established accuracy and time criteria for section proficiency. More so than any other weapon system, the field artillery is procedurely oriented. There are precise procedures to be followed by each section for each category and type of mission. In order of complexity, the procedures appear to be most complex at the FDC level, moderately so at the Observer level and least complex at the Howitzer section level. This appears to be so because the procedures at the FDC level are virtually unique to each category and type mission, while at the Observer and Howitzer Section levels there appears to be much overlap. For example an Observer who is competent in locating a target and conducting an adjustment in an "Adjust Fire" mission is generally competent to locate a target and conduct an adjustment in many other types of missions requiring those functions. The same may be true for Howitzer sections.

If this premise is accurate one could conclude the following:

A. An FDC which is thoroughly drilled in the required procedures for each type mission can obtain a very high degree of proficiency by CPX type exercises coordinating with the Observer and Howitzer sections of the battery and/or by use of the M 31 trainer. Live firing does little for the FDC other than to validate its proficiency.

B. An Observer is less procedurally oriented than the FDC and does require a degree of live firing to obtain knowledge of such subjects as 1) the effects of ammunition fuze combinations 2) implementation of adjustment procedures, particularly judgments in sensings and corrections 3) real life problems which cannot be adequately simulated. Many of the procedures and experiences learned by the Observer in a common type "Adjust Fire" mission are directly transferable to other type missions. The M 31 trainer can provide a fair degree of experience in the implementation of adjustment procedures.

C. The Howitzer Sections have the least degree of complexity in the area of procedures. There are a limited number of possible methods of fire, projectile-fuzing-charge combinations and other considerations for each type mission. This is not to imply that training Howitzer Sections is less complicated than training other sections. It is only procedurally less complex. Since current training devices do not go far in simulating the combat environment for the Howitzer sections, there is a requirement for live firing.

D. At the battery level, there appears to be a requirement for some degree of live firing to enable the battery commander to validate the proficiency of his unit.

E. Based upon the heavy orientation of Field Artillery toward procedures, it is suggested that some degree of live firing is required to train some sections and to validate proficiency. However, the degree of live firing required to accomplish these objectives is substantially less than the quantity of ammunition currently authorized.

Please consider the above statements and provide your observations, concurrence, non concurrence, or position on this subject.

Comments on FDC

Comments on Observer

Comments on Howitzer Sections

Comments on Battery Level

86. From the theoretical approach, one may debate what degree of proficiency is attainable in Field Artillery with extensive training in procedures with a minimum of live firing. It is recognized that personnel who are well motivated are more susceptible to learning and to being proficient. How would you evaluate the value of live firing on the morale or motivation of Artillery personnel?

A. ___ live firing is critically important to maintaining high unit morale

B. ___ live firing is not critical but is an important factor in providing a confidence level in the section and battery capability to perform.

C. ___ live firing is only one of many factors influencing the unit morale or motivation. It is not necessarily a primary factor.

D. ___ live firing is not a significant factor in the ability of the battery to perform at a high degree of proficiency.

The following questions deal with two subjects: 1) the relative difficulty of learning how to conduct a given type of mission and 2) the relative difficulty in coordinating a given type of mission. For purposes of this comparison, let us compare or relate the difficulty of learning and coordinting missions to the difficulty of learning and coodinating an "Adjust Fire" type mission.

87. Is the conduct of a registration (Precision, HB or MPI) more difficult to learn than the conduct of an "Adjust Fire" mission? (Select 1)

___ No, it is easier
___ the degree of complexity is about the same
___ the registration is slightly more difficult
___ the registration is materially more difficult
___ the registration is one of the most difficult missions to conduct

88. Is the conduct of a registration more difficult to coordinate than the conduct of an "Adjust Fire" mission (Select 1)

___ no, it is easier to coordinate
___ the degree of complexity is about the same
___ the registration is slightly more complex to coordinate
___ the registration is materially more complex to coordinate
___ the registration is one of the most difficult to coordinate

89. Is the conduct of an Illumination mission without HE, more difficult to learn than the conduct of an "Adjust Fire" mission?

___ no, it is easier
___ the degree of complexity is about the same

___ the registration is slightly more complex to learn
___ the registration is materially more complex to learn
___ the registration is one of the most difficult to learn

90. Is the conduct of an Illumination mission without HE more difficult to coordinate than an "Adjust Fire" mission?.

___ no, it is easier to coordinate
___ the degree of complexity is about the same
___ the illumination is slightly more complex to coordinate
___ the illumination is materially more complex to coordinate
___ the illumination is one of the most difficult to coordinate

91. Is the conduct of a coordinated Illumination/HE mission more difficult to learn than an "Adjust Fire" mission?

___ no, it is easier
___ the degree of complexity is about the same
___ the coordinated mission is slightly more complex to learn
___ the coordinated mission is materially more complex to learn
___ the coordinated mission is one of the most difficult to learn

92. Is the conduct of a coordinated Illumination/HE mision more difficult to coordinate than an"Adjust Fire" mission?

___ no, it is easier to coordinate
___ the degree of complexity is about the same
___ the coordinated mission is slightly more complex to coordinate
___ the coordinated mission is materially more complex to coordinate
___ the coordinated mission is one of the most difficult to coordinate

93. Is the conduct of a Smoke mission more difficult to learn than an "Adjust Fire" mission?

___ no, it is easier to learn
___ the degree of complexity is about the same
___ the smoke mission is slightly more complex to learn
___ the smoke mission is materially more complex to learn
___ the smoke mission is one of the most difficult to learn

94. Is the conduct of the Smoke mission more difficult to coordinate than an "Adjust Fire" mission?

___ no, it is easier to coordinate
___ the degree of complexity is about the same
___ the smoke mission is slightly more complex to coordinate
___ the smoke mission is materially more complex to coordinate
___ the smoke mission is one of the most difficult to coordinate

95. Is the conduct of the ICM/FASCAM mission more difficult to learn than the "Adjust Fire" mission?

___ no, it is easier to learn
___ the degree of complexity is about the same

___ the ICM/FASCAM is slightly more complex to learn
___ the ICM/FASCAM is materially more complex to learn
___ the ICM/FASCAM is one of the most difficult to learn

96. Is the conduct of the ICM/FASCAM mission more difficult to coordinate than the "Adjust Fire" mission?

___ no, it is easier to coordinate
___ the degree of complexity is about the same
___ the ICM/FASCAM is slightly more complex to coordinate
___ the ICM/FASCAM is materially more complex to coordinate
___ the ICM/FASCAM is one of the most difficult to coordinate

END

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